plating

JOURNAL OF THE AMERICAN ELECTROPLATERS' SOCIETY

SEPTEMBER · 1961

PLATING MAGAZINE

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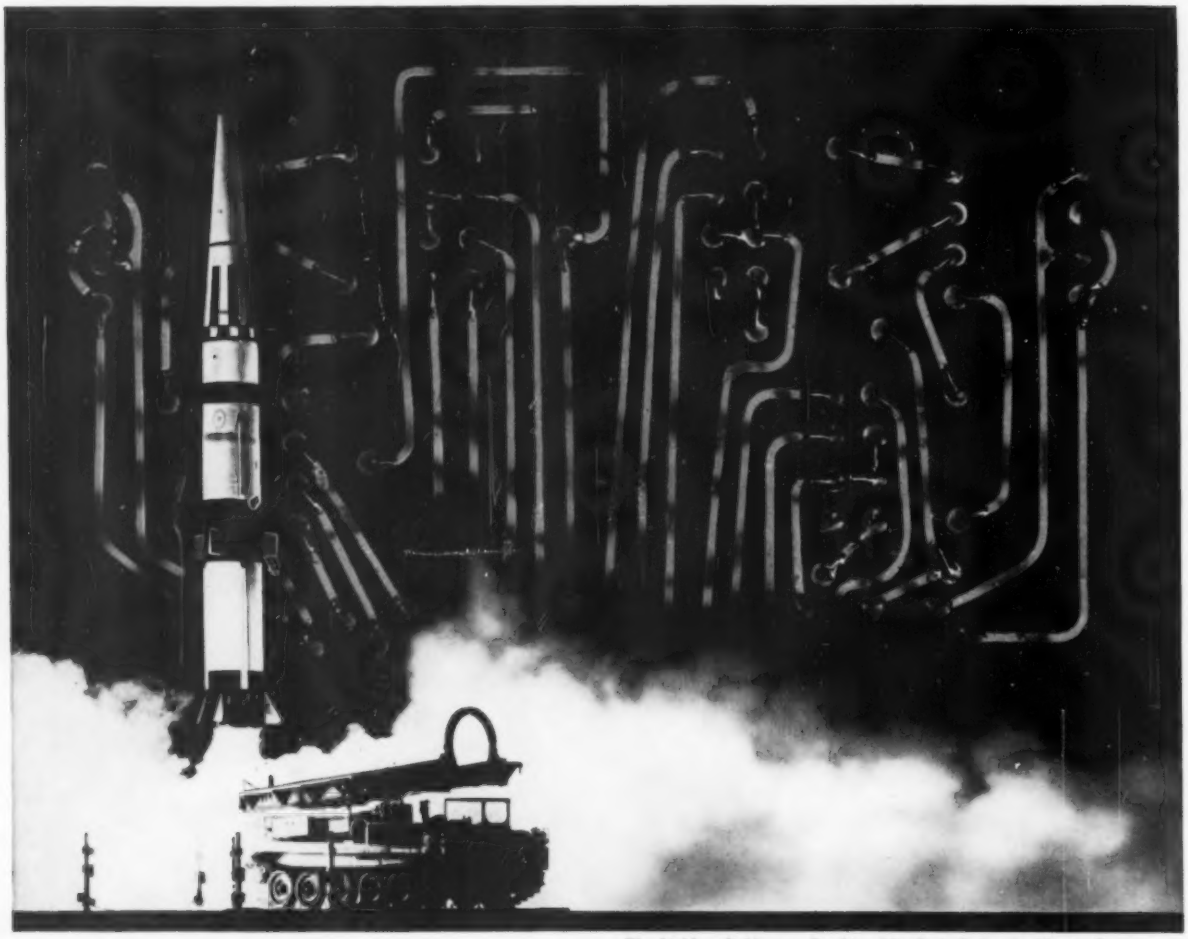

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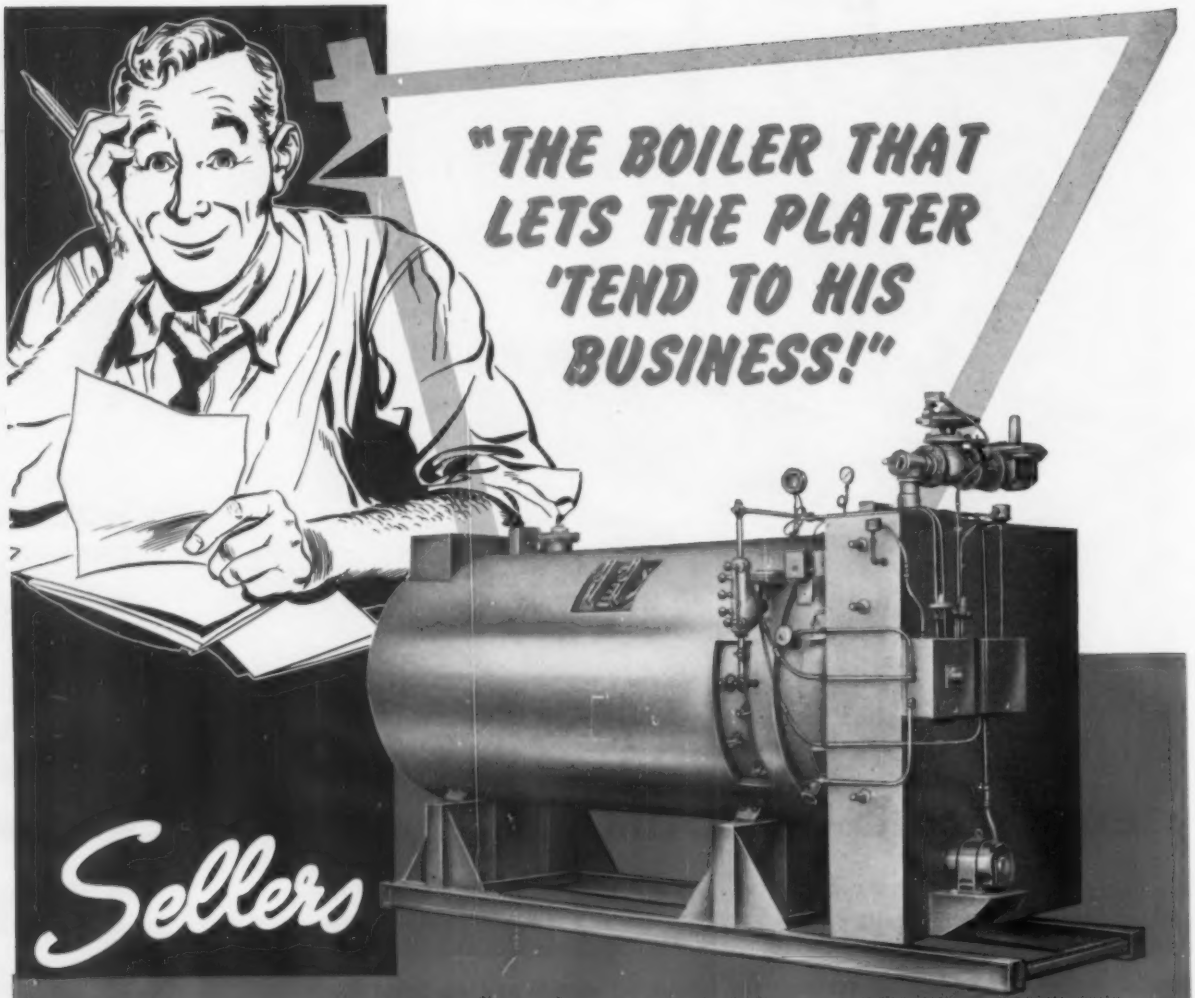

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JOURNAL OF THE AMERICAN ELECTROPLATERS' SOCIETY

SEPTEMBER 1961 — **Vol. 48, No. 9**

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EDITORIAL

AES STANDARD SPECIFICATIONS

AS A NON-PROFIT Society dedicated to the improvement of the art and science of metal finishing, is it proper for the American Electroplaters' Society to endorse standard specifications for coatings? Its Constitution and Bylaws are silent on this question. To this writer, it seems clear, however, that endorsement of standard specifications by the AES, if the latter are prepared as a result of controlled tests and with due regard to available scientific knowledge, can be a most effective aid to improvement of the art of metal finishing. To this extent, therefore, this appears to be within the sphere of action for the Society.

It may come as a surprise to many readers that the AES is indeed already active in this area. There are and have been for many years, AES-endorsed standard specifications for plated coatings. Due to a fortunate circumstance, it has been and is possible for the Society to endorse certain standards which are prepared by a sister Society after elaborate and sometimes costly testing programs. In practice, this comes about as follows.

Some of the members of the American Society for Testing Materials (ASTM) Committee B-8 specification-writing subcommittee who are most knowledgeable in the field of behavior of plated coatings are simultaneously members of a subcommittee of the AES Research Committee. Accordingly, it is thus possible for the Research Committee to recommend certain ASTM standards for endorsement to the AES with confidence that they are based upon sound technical principles. The approved specifications are then published by ASTM, with AES endorsement, and are made available to the public at modest cost on direct order from the ASTM.

Many of us in the electroplating and metal finishing industry here are observing with great interest the program recently instituted in Great Britain which is a scheme for labeling the quality of plated coatings—a sort of hallmarking program where the label represents the guarantee of the producer that the coating conforms to a quality specification indicated at a glance by the color and number of an appended tag or label. This scheme could well be an answer to the quality problem in one large field, namely consumer products, provided that the specifications for a given label are not frozen for all time but can be revised upward as better coatings are developed by research.

In this country, there exists a plethora of independent specifications for metal finishes set up by large industrial corporations, by the armed forces and other government agencies. A given supplier may be required to meet different, even conflicting, standards for similar products in filling orders from different purchasers. Some specifications show clearly that the engineers who prepared them were endowed with little knowledge of the advances made in metal finishing in the past 25 years. AES members faced with such difficulties may do well to consider the use of ASTM/AES standards in contracts where these are applicable so as to encourage uniformity and improved quality of the products of the metal finishing industry.

W. Andrew Wesley

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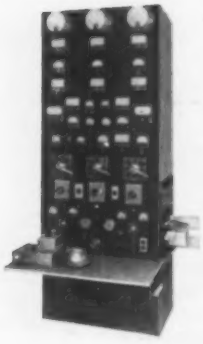

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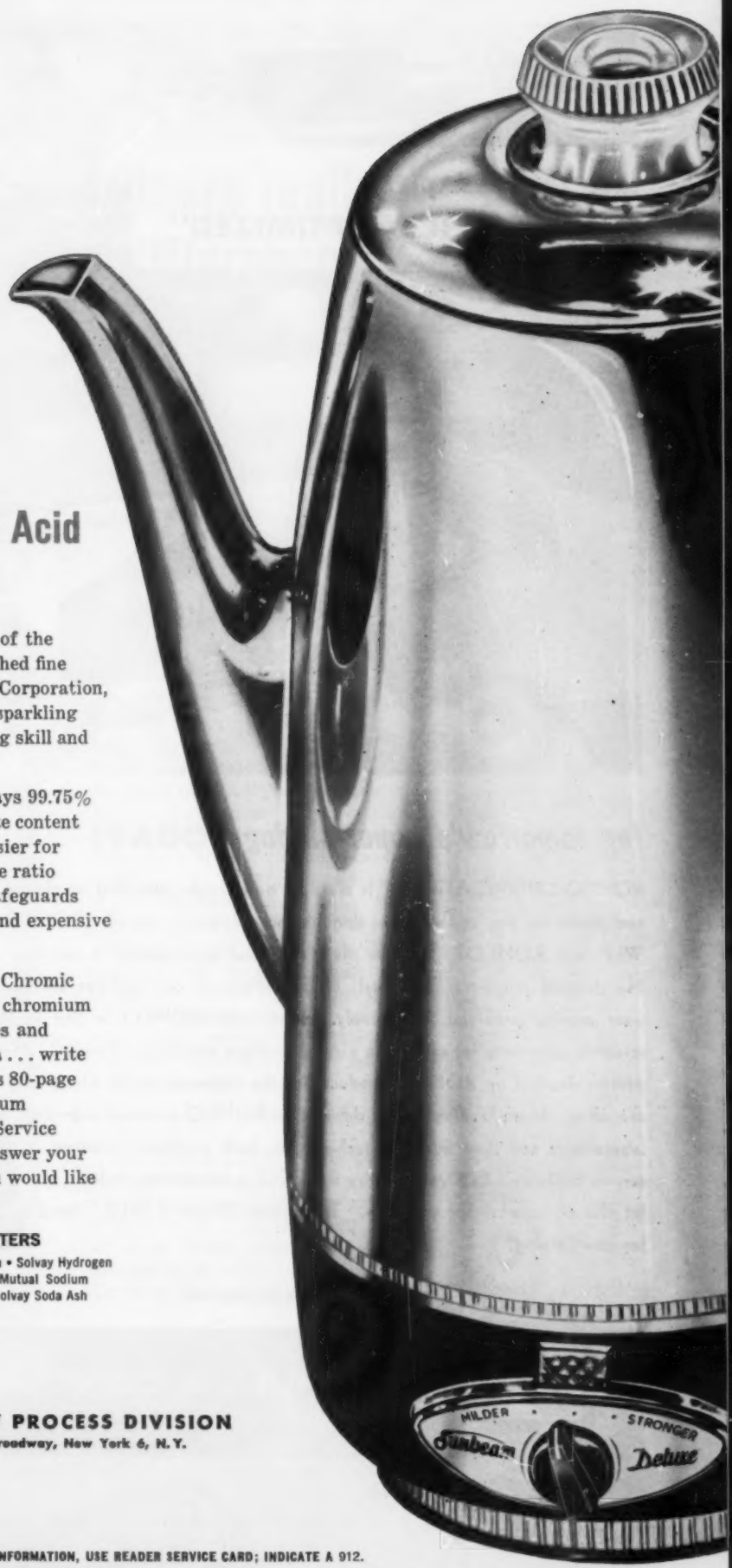

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Chemical Milling by C. H. Rose, Watervliet Arsenal, Watervliet, N. Y. December 1960. 21 pp. (Order PB 171 112 directly from the Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce, Washington 25, D. C., price 75 cents.)

While removal of metal through chemical erosion is nothing new, only now, according to the study, have techniques been perfected to apply chemical milling accurately and precisely enough to produce highly complex shapes, non-symmetrical patterns, intricately stiffened structures, and tapered skin. Breakthrough in the field is attributed to (1) new organic coatings and tapes resistant to different types of solution, (2) compounded or modified etching solutions that give uniform etching rates without destroying the physical or chemical properties of a metal, and (3) electronic measuring and control equipment.

Some of the materials that have been successfully milled with chemicals are aluminum alloys, steel, stainless steel, titanium, magnesium and mag-thorium. Cobalt nickel alloys are said to be yielding to research effort. Obstacles constantly presented by introduction of new materials may be surmounted by chemical milling.

Advantages of chemical milling over machine milling are cited. Also, no highly skilled operators are required for chemical milling, and the process lends itself easily to automation. The number of parts that can be milled simultaneously is limited only by the size and number of tanks and the shape of the part to be milled. Nor are sanding and polishing required since chemical milling in many cases improves the finish of castings.

ASM Review of Metal Literature, 1960, edited by Marjorie R. Hyslop and published by the American Society for Metals, Metals Park, Ohio. Vol. 17, June, 1961. Cloth, 6 by 9 inches, 1342 pages, $25.00.

This book contains 11,903 annotations of articles, technical papers, reports and documents appearing in engineering, scientific and industrial journals and books throughout the world during 1960. The book is divided into 20 sections covering different areas of materials and process engineering and technology, and includes addresses of publications as well as comprehensive subject and author indexes.

Back issues of Volumes 1 through 16, 1944–1959, also are available at $20.00 per copy directly from American Society for Metals.

Electropolishing and Chemical Polishing of High-Strength, High-Temperature Metals and Alloys. (DMIC Memo 98) by J. A. Gurklis and others, Defense Metals Information Center, Battelle Memorial Institute. April 1961. 15 pp. (Order PB 161 248 directly from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 50 cents.)

Electropolishing and chemical polishing, two nonmechanical methods of surface finishing metal, are described in this memorandum. Both methods can be used to remove "smeared and distorted" metal left on the surface by mechanical finishing methods. They produce no surface "skin" having different structure and properties from the bulk of the metal and provide more dependable surfaces for anti-friction uses. In addition, improved corrosion resistance is often obtained by the use of these processes because of the absence of differential stresses that result when mechanical finishing is done.

In electropolishing, the work is connected to the positive lead from a direct-current source. Thus, the work is made the anode in the electrolytic circuit, and the cathode is connected to the negative terminal of the direct-current source and may be any metal (or carbon) that is chemically resistant to the electrolyte. Equipment layout, and handling of work as to racking or holding are similar to electroplating operations. In chemical polishing, the work is chemically attacked by the electrolyte to produce a surface finish which, in principle, should have the characteristics of an electropolished surface.

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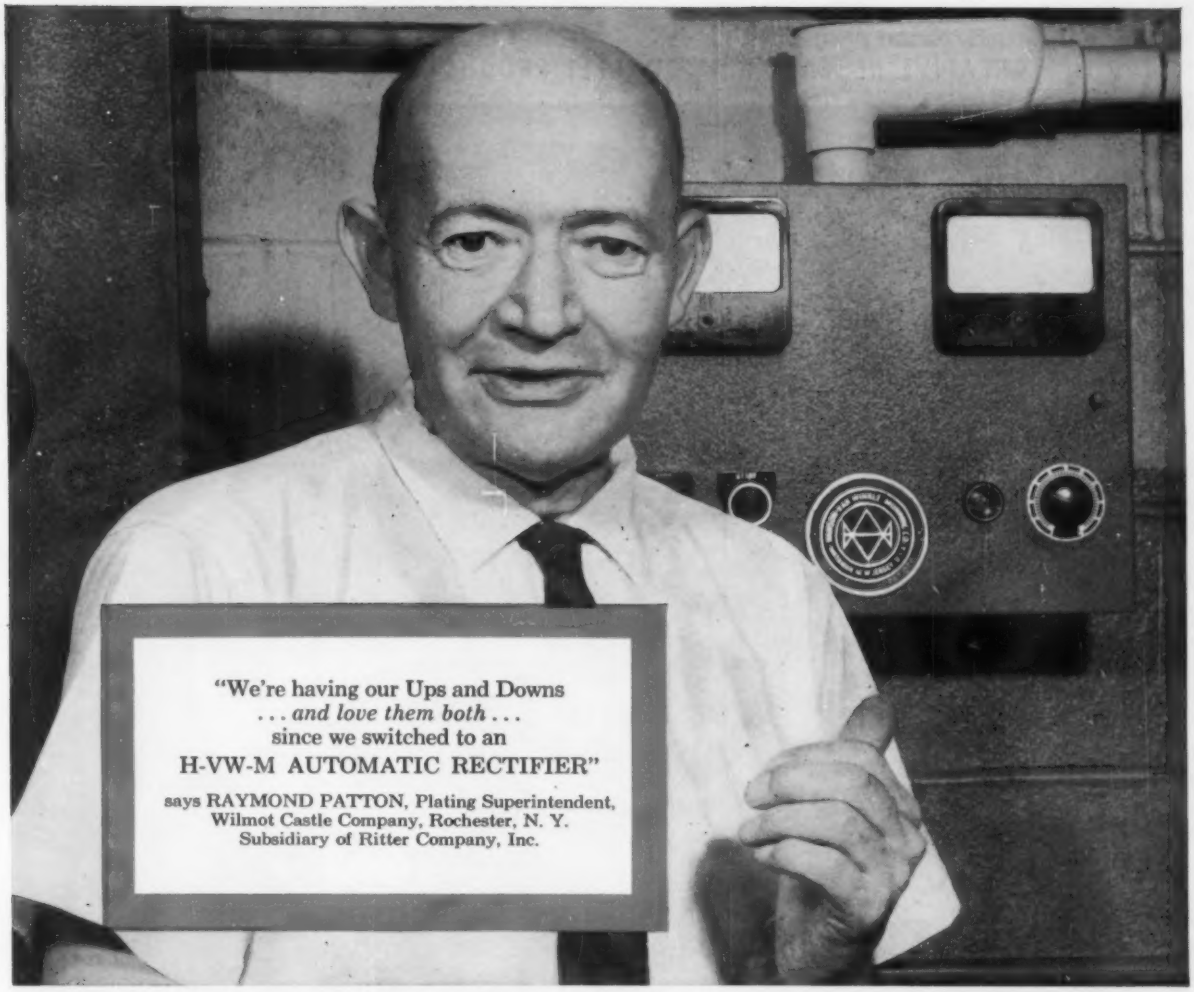
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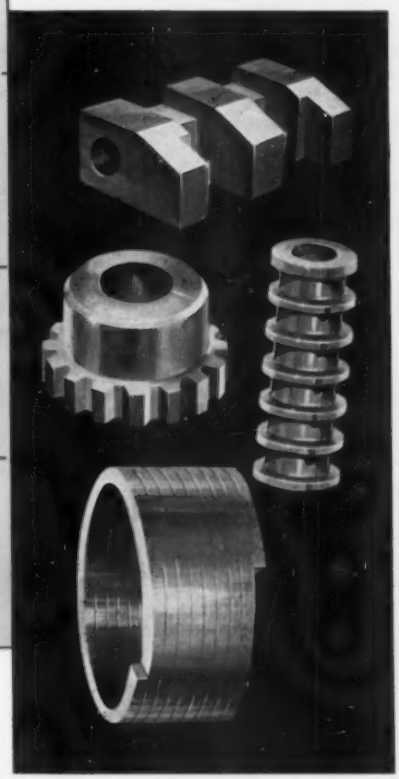

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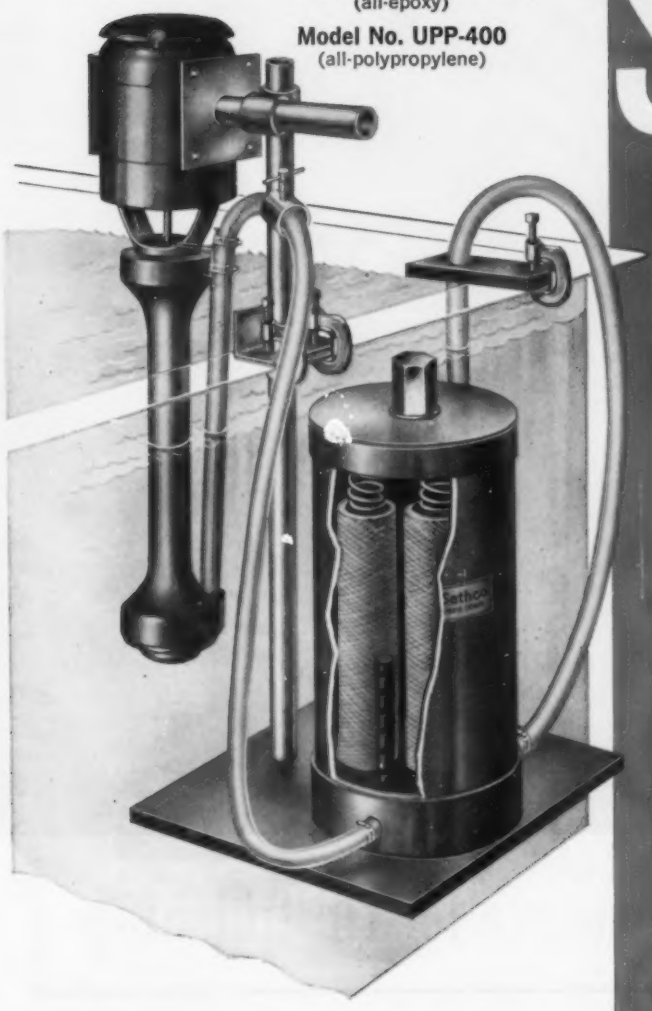

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♦

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♦

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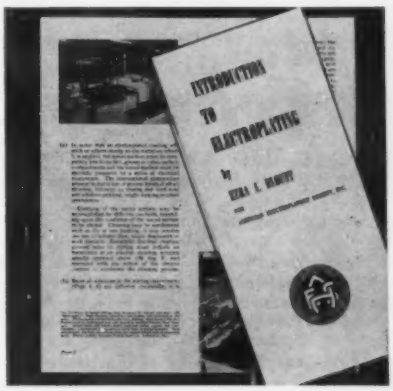

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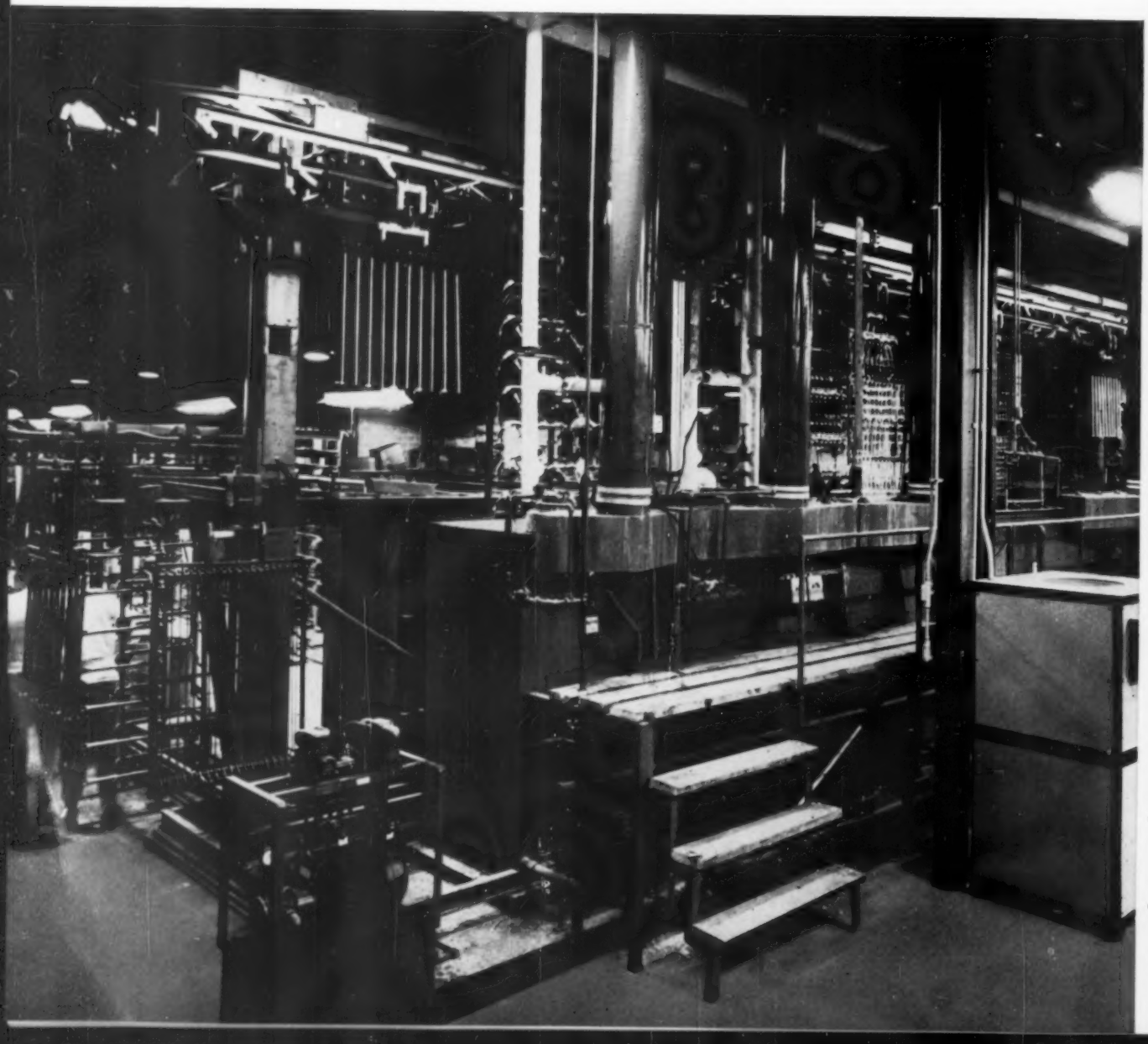

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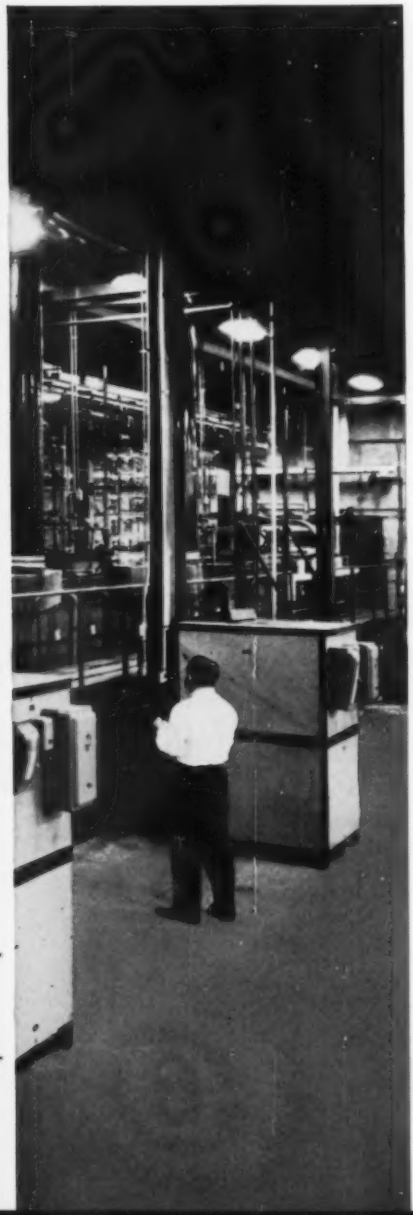

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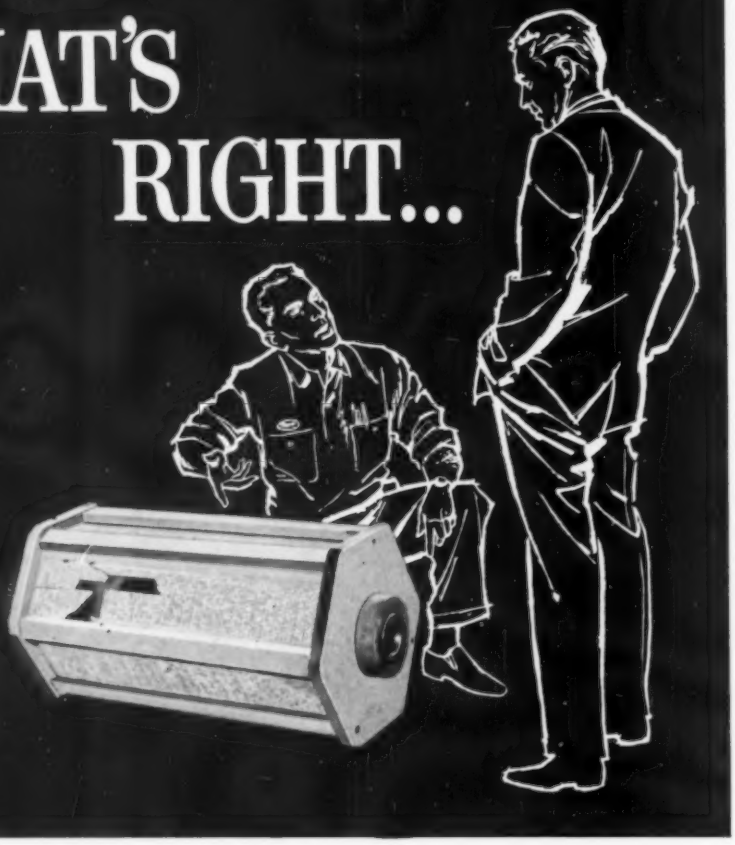

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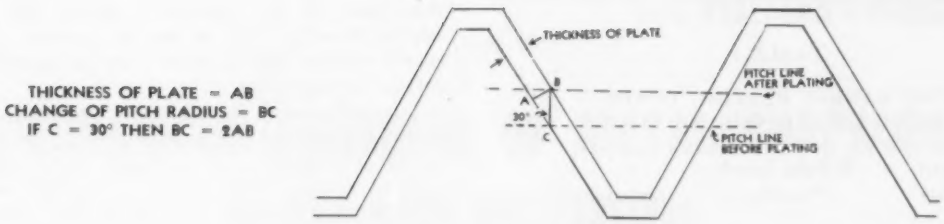

Fig. 1. Change of pitch diameter during plating.

BARREL PLATING OF LONG LENGTH FASTENERS

by W. R. CRAWFORD*

THE PROBLEM

IT IS AN ACCEPTED fact that the barrel plating of longer fasteners and threaded rods presents definite problems. In many cases it is a physical impossibility, due to the probability of the parts bending. In other cases, it is economically advantageous to rack or wire the parts to obtain a better, more uniform deposit. In still other cases, the parts may tangle and become wrapped around the danglers causing damage to the dangler cables. The most serious problem, however, is the difficulty of obtaining a satisfactory deposit on the center of the long, threaded parts without building-up the lead threads to the point where the part will not enter the gage, or tapped hole.

During plating, the metal does not deposit uniformly on the parts being plated. The rate of deposit will be affected by various factors such as the operating conditions of the bath, the throwing power, the current density and the geometry of the part being plated. The effect of the geometry is magnified in the plating of fasteners as the pitch diameter of the parts increases at a rate of four times the deposit on a flat surface.

Figure 1 illustrates this more rapid change in pitch diameter. The thickness measured on the head of the screw is, of course, measured at a 90° angle to the surface. The change in pitch diameter, however, is measured at an angle of 30° to the surface. The pitch radius therefore changes at a rate of twice the plating thickness and consequently the pitch diameter changes at four times the plating thickness on the head.

It can be seen that on an easily plated fastener such as a 0.25 in. by 20 by 1 in. bolt, assuming a virtually uniform deposit, an increase of 0.0008 on the pitch diameter must be allowed if the head is to have a deposit of 0.0002 in.

BARREL LOADING

It is generally accepted that barrel loads are determined by the area of the parts to be plated. A widely used figure is that a 14 by 30 in. barrel load would normally be 60 square feet and that such a load at 600 amp would receive a deposit of 0.0001 of zinc in 10 minutes of plating. The question is where would the 0.0001 of zinc be deposited? On longer threaded parts such as a 0.25 by 6 in.-bolt or No. 10 by 4 in. screw, the deposit would be preferentially on the heads or lead threads with little or indeed no plating in the center of the part. In many cases only experience can show what load can be run and the concept of area must be discarded. In zinc plating fasteners in our installation using a fully automatic machine with 14 by 30 in. barrels, 18 volts, with 800 to 900 amperes per barrel, it is found that the loads of a given diameter, such as 0.25 in. as outlined in Table I, can be satisfactorily plated.

Although loads for other diameters would vary, the trend of less weight and less areas for longer lengths would remain.

The build-up of the ends of threaded rods is visually shown in Fig. 2. The parts are 0.25 by 5.5 in. and 0.375 by 4 in. threaded rods used as scrap for mixing with smaller loads in barrel nickel plating to improve contact. They are used for extended periods before being discarded, and so have very heavy deposits. On these parts the thickness is 0.025 in the center, and ranges to 0.072 on the end.

With a given diameter, the longer the parts the greater the difference between the thickness of the deposit on the end, or head, and the thickness at the center.

PREDICTING PLATING BUILD-UP

As it would be of some value to predict the plating build-up to expect on the lead threads of a part for a minimum plating

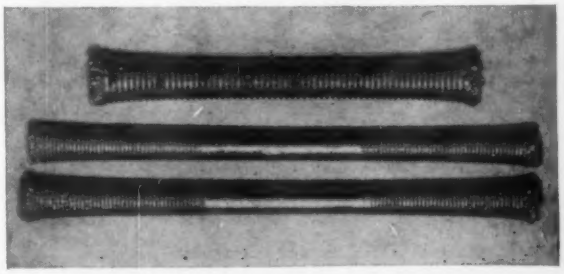

Fig. 2

*Vice President and General Manager, Chrome-Rite Company, Chicago, Illinois.

TABLE I

ZINC BARREL PLATING LOADS
FOR 1/4 INCH DIAMETER BOLT

Length Inches	Weight/Load Pounds	Area/Load
1	170	105 ft²
2	140	73 ft²
3	120	60 ft²
4	100	47 ft²
5	85	37 ft²

at the center, the data shown in Fig. 3 were compiled. This figure shows the amount of plating deposited on the head of a fastener when 0.0001 of zinc is deposited on the midpoint of the shank. A comparison of the thickness on the head to the thickness in the center was chosen because of the relative difficulty in determining accurately the plating thickness on the threaded areas. Thickness determinations were made through the use of drop test or Magna Gage. A minimum of three parts were checked from a barrel load, and many barrel loads were checked over a period of three months. The thicknesses reported are average thicknesses of all parts from all loads for a given length of bolt. Although a given barrel load may vary in average thickness from part to part, the trend of heavier deposits on the head and lead threads than on the center of the piece remains.

The parts used were 1/4, 5/16 and 3/8 in. bolts, from two to six inches in length. A relatively greater thickness build-up was expected on the smaller diameters than on the 3/8 in. diameter. This was not the case, however, and can probably be attributed to experimental error and the limited 10 per cent accuracy of the methods available for thickness determinations. It was expected, however, that quite some smaller diameters, such as Nos. 6 or 8 would give a much greater relative build-up in the 2 to 6 in. lengths than would 0.25 in. or larger bolts.

As already stated, Fig. 3 shows the amount of plating deposited on the head of a fastener when 0.0001 of zinc is deposited at the midpoint of the shank. These figures of course apply to work produced at the author's plant under standard conditions and might vary somewhat under different conditions of deposition. As outlined above, geometry is but one factor in the many variables affecting the rate of deposition. Fig. 3 shows the relative importance of this factor.

The curve in Fig. 3 indicates that on a 0.25 by 5 in. bolt, one would expect 0.00035 on the head or lead thread for a deposit of 0.0001 in the midpoint of the shank. If the specification were to require a minimum of 0.0002 on the shank, 0.0007 on the head or lead thread would be expected. As the pitch diameter changes at four times the rate on a flat surface, it would be expected that an 0.0028 increase in the pitch diameter would obtain 0.0002 deposit on the shank of the part.

The standard maximum pitch diameter on a 0.25 in. by 20, Class 2A before plating thread is 0.2164 and the standard maximum pitch diameter on a 0.25 in. by 20, Class 2 after plating thread is 0.2175. Using the same example of a 0.25 by 5 in. bolt described above, if the part is manufactured at the maximum 2A pitch diameter, the plater would be allowed an increase of 0.0011 in the pitch diameter during plating. This in turn would allow a maximum deposit of 0.0011 divided by 4, or 0.00027 on the head or lead threads. Again from Fig. 2, it can be calculated that a deposit of 0.00027 on the head would result in a deposit of 0.00008 on the center of the shank. Such a thin deposit is of doubtful value and would probably result in a dark or discolored finish that would be entirely stripped during bright dipping or chromating. This example should point out the absolute necessity of the manufacturer rolling the threads of longer length fasteners to the lower allowable limits if he is to expect a satisfactory barrel plated finish.

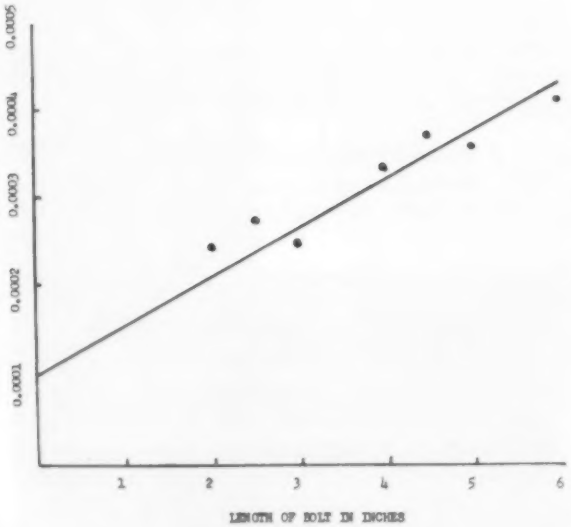

Fig. 3. Build-up of zinc plating on longer length bolts.

Weldon R. Crawford, vice president and general manager of Chrome-Rite Company, Chicago, Illinois received a BS in chemistry from Beloit College 1950, and did graduate work in chemistry at Northwestern University. He is a member of Phi Beta Kappa, Omicron Delta Kappa, American Electroplaters' Society, past chairman of the Chicago Electro Platers Institute, and a director of the National Association of Metal Finishers. He served for 3½ years as a Naval Officer during the Korean War.

MECHANICAL FINISHING OF METAL SURFACES

I. ZINC BASE DIE CASTINGS

A. Bar Compounds

PART 3

by WILLIAM C. GEISSMAN*, R. SCOTT MODJESKA** and KENNETH GATCHEL*

COMPOUND APPLICATION

Since nothing had been published concerning the characteristics of motor driven automatic applicators, it was imperative that some data be obtained concerning their use. The object of the first test was to determine the uniformity of compound removal from the bar while using the applicator. The amount of compound removed from the bar was determined by weighing the bar before and after 25 strokes against the wheel while continually buffing the standard test piece at 25 pounds pressure, 4500 SFPM, and a linear speed of 15 feet per minute. The results of this test are shown in Table XI. The average per stroke was 1.972 grams. The theoretical average per stroke was then calculated by mathematically determining the weight of the bar that should be worn away by moving the bar 250 times against the wheel. This was determined to be 1.964 grams and thus two average figures are in remarkably close agreement. However, it is apparent that the results of the individual tests were not consistent.

A study of the relationship between compound deleted from the bar and that retained by the wheel at various surface conditions of the wheel using the automatic applicator was made. In Table XII: rake means a thorough raking of the wheel with a nail board; O.R. designates a medium type of raking with the blunt end of a file; T.P. denotes that a test piece was passed under a wheel with 25 pounds pressure four times (two cut and two color) and the wheel was then lightly raked with the file. After the wheel was prepared as noted in the table, the bar compound and the wheel were weighed before and after the application of compound and the determinations as noted in Table XII were made. From these results it is readily apparent that the amount of compound either removed from the bar or retained on the wheel is far from consistent. The automatic applicator is hardly a scientific method for administering compound to a wheel, but its use should give more satisfactory results than those achieved manually.

In order to put more compound on the wheel per stroke and to further verify the conclusions arrived at previously, a double lead screw was placed in the applicator to make it possible to apply twice as much compound on the wheel in a given stroke as with the single lead screw. The results shown in Table XI again demonstrate that the results of the individual tests were not consistent. However, the theoretical average per stroke of 3.04 grams does not compare with the measured average per stroke of 3.34 grams as closely as was found with the single lead screw. This might be explained by assuming that the more rapid movement of the bar against the wheel actually knocked bits of compound from the bar into space. Table XIII contains data obtained in the same fashion as noted previously for the single lead screw.

TEMPERATURE DETERMINATIONS

To determine the temperatures that might be attained when a piece is being buffed the following procedure was adopted (see Fig. 14): The same piece was used as in the other tests. A hole was drilled and tapped in the piece to accommodate a 4-40 screw. A hole was drilled through the screw and a 24 guage Chromel-Alumel thermocouple was inserted into the screw through the head, and soldered into place; thus the screw could be threaded into the piece and held in place by a nut with the thermocouple lead wire coming out of the bottom of the part and the junction of the couple lying on the top surface. The couple was twisted through the length of the screw so that temperatures could be recorded

TABLE XI
AMOUNT OF COMPOUND REMOVED FROM BAR WHILE USING AUTOMATIC APPLICATOR

Single Lead Screw Applicator		Double Lead Screw Applicator	
Grams of Compound Removed from Bar in 25 strokes	Grams of Compound Removed from Bar in one stroke	Grams of Compound Removed from Bar in 15 strokes	Grams of Compound Removed from Bar in one stroke
43.4	1.74	45.0	3.0
52.9	2.12	45.0	3.0
53.4	2.14	51.2	3.41
40.8	1.63	56.6	3.77
46.5	1.86	60.0	4.00
54.6	2.18	50.8	3.38
50.5	2.02	52.6	3.50
51.5	2.06	47.4	3.16
54.8	2.19	43.3	2.88
44.7	1.79	46.0	3.06
		51.1	3.41
		53.0	3.53

*National Lock Company, Rockford, Illinois.
**Scientific Control Laboratories, Inc., Chicago, Illinois.

even after the piece had been severely cut down. Temperature readings were made by means of a potentiometer calibrated for chromel-alumel couples. During all of the tests the piece was held stationary with the buff in the same relative position to the thermocouple. It was not possible to determine the temperature while the part was moving under the buff as in the previous part of the work, because the temperature rose and fell much too fast to be measured by the potentiometer.

While this method of temperature measurement was first being investigated, the part was buffed at 25 pounds pressure, 4500 SFPM, and without compound being applied; a temperature of 160F was then attained. However, the application of compound brought an immediate temperature rise to 260F.

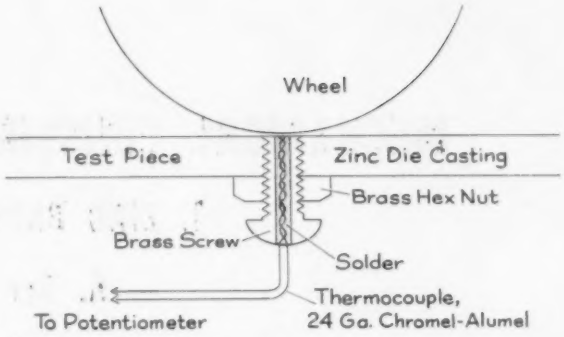

Fig. 14. Thermocouple assembly for temperature measurements.

TABLE XII

RELATIONSHIP BETWEEN COMPOUND DELETED FROM THE BAR AND THAT RETAINED ON THE WHEEL, USING AUTOMATIC APPLICATOR WITH SINGLE LEAD SCREW

6000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 10 Strokes

Rake	2.4	2.02
O.R.	2.33	2.33
T.P.	2.15	1.88

Grams Compound on Wheel per Stroke, Average of 4 Strokes

Rake	1.175	1.225	1.1	.7
O.R.	1.2	.825	.72	.875
T.P.	1.275	1.125	.97	1.15

Average per Stroke—on Wheel ..... 1.00 grams
Average per Stroke—from Bar ..... 2.16 grams

5000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 10 Strokes

Rake	1.66	1.56
O.R.	1.67	1.87
T.P.	1.53	1.97

Grams Compound on Wheel per Stroke, Average of 4 Strokes

Rake	1.5	.8	.825	1.125
O.R.	1.25	1.45	.9	1.275
T.P.	1.40	1.3	1.125	1.225

Average per Stroke—on Wheel ..... 1.18 grams
Average per Stroke—from Bar ..... 1.71 grams

4000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 10 Strokes

Rake	2.12	1.98
O.R.	2.15	2.16
T.P.	2.07	2.17

Grams Compound on Wheel per Stroke, Average of 10 Strokes

Rake	9.25	0.95	1.225	0.9
O.R.	.85	1.025	1.025	1.075
T.P.	.85	1.2	1.0	1.45

Average per Stroke—on Wheel ..... 1.02 grams
Average per Stroke—from Bar ..... 2.01 grams

TABLE XIII

RELATIONSHIP BETWEEN COMPOUND DELETED FROM THE BAR AND THAT RETAINED ON THE WHEEL USING AUTOMATIC APPLICATOR WITH DOUBLE LEAD SCREW

6000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 4 Strokes

Rake	4.575	2.325	5.225
O.R.	3.625	3.12	3.325
T.P.	4.400	3.425	3.7

Grams Compound on Wheel per Stroke, Average of 4 Strokes

Rake	1.4	1.45	1.55	1.675
O.R.	1.375	2.05	2.125	1.625
T.P.	1.65	1.65	1.875	2.075

Average per Stroke—on Wheel ..... 1.71 grams
Average per Stroke—from Bar ..... 3.75 grams

5000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 4 Strokes

Rake	2.875	3.0	2.375
O.R.	4.25	3.7	2.925
T.P.	2.7	4.05	3.9

Grams Compound on Wheel per Stroke, Average of 4 Strokes

Rake	2.725	1.95	2.125	2.65
O.R.	2.325	2.525	2.025	2.3
T.P.	2.025	2.2	1.975	2.225

Average per Stroke—on Wheel ..... 2.25 grams
Average per Stroke—from Bar ..... 3.3 grams

4000 SFPM

Grams Compound deleted from Bar per Stroke, Average of 4 Strokes

Rake	2.375	2.65	4.15
O.R.	4.00	4.05	3.25
T.P.	2.7	3.9	2.825

Grams Compound on Wheel per Stroke, Average of 4 Strokes

Rake	2.25	2.05	2.05	2.55
O.R.	2.3	2.1	2.275	1.975
T.P.	1.925	2.4	2.125	2.1

Average per Stroke—on Wheel ..... 2.16 grams
Average per Stroke—from Bar ..... 3.32 grams

TABLE XIV
TEMPERATURES ATTAINED AT SURFACE OF PART DURING BUFFING AT NOTED CONDITIONS USING AN AUTOMATIC APPLICATOR

SINGLE LEAD SCREW APPLICATOR

Pressure in Pounds	Surface Feet per Minute						
	3500	4000	4500	5000	5500	6000	6500
	Temperature in degrees Fahrenheit						
19	237	237	222	235	242	245	237
25	265	272	260	280	302	287	252
31	317	317	330	327	325	302	265

DOUBLE LEAD SCREW APPLICATOR

Pressure in Pounds	Surface Feet per Minute								
	3500	4000	4500	5000	5500	6000	6500	7000	8000	9000
	Temperature in degrees Fahrenheit									
19	274	284	296	313	299	295	259	275	263	292
25	317	325	318	329	319	310	270	320	272	302
31	329	335	345	340	337	330	298	343	310	327

This temperature increase was lost in a short time and the temperature receded to 160F. An application of compound again brought the same increase in temperature and after a short time the temperature again settled back as previously observed. While maintaining the same pressure and speed, the same performance was repeated four times. This experience led to the use of the automatic applicator while making temperature determinations.

The data shown below in Table XIV were obtained by running the wheel at the noted pressures, speeds, and with the applicator with the single lead screw and the double lead screw. The temperature was recorded when it reached the equilibrium point. It should be noted that the recorded temperatures are the averages of the high and low values. The readings vary by about ten degrees. Thus, for a recorded reading of 280F, the low would be 275F and the high 285F. The high temperature occurred immediately after the compound was applied, and the low temperature just prior to the administration of compound when it was at the point of depletion. All observations were made after the wheel was lightly raked. The applicator was running continually while the test was being made. The equilibrium temperature was reached within about five seconds. The readings were checked once or twice and were remarkably consistent if the condition of the wheel was kept uniform by adequate raking. A noticeable drop in temperature was observed when the wheel was allowed to glaze over by not raking frequently. If we may assume that the amount of work done is indicated by the temperature attained, this observation would check with the practice of experienced buffers who rake out a wheel to increase efficiency.

These results indicate that the amount of buffing done is indicated by the temperature attained. The increase in pressure showed an increase in temperature, and it was demonstrated that an increase in pressure produces more work. The increase in the amount of compound used also produced higher temperatures and more buffing. It should be noted that the higher wheel speeds used with the double lead screw did produce higher temperatures which is inconsistent with our buffing results. However, it was observed that the wheel tended to glaze over rather quickly, and the heat produced on the piece was that given by friction and not by any real cutting action that would produce a truly buffed surface.

BUFFING TESTS USING THE AUTOMATIC APPLICATOR

Two blocks of buffing tests were performed using the automatic applicator, one with the single lead screw and the other with the double lead screw. This work was done to determine if the applicator could utilize compound more effectively than the manual method.

In Table XV a single lead screw was used in the applicator and the piece received six "shots" of compound of approximately two grams each, making a total of about 12 grams. In Table XVI the double lead screw was used in the applicator and the piece received six shots of compound of approximately 3.3 grams each, for a total of about 19.8 grams.

It is readily seen that the 19.8 grams did a much better job than the 12 grams. From the previous tests it is found that the 12 grams of compound gave slightly inferior results than the manually applied 30 grams of compound. However, the 19.8 grams exhibited the best performance of any test made thus far.

It should be mentioned, that in one instance during the above tests, that the 850 gram scratch lines were erased and an adjacent set of 650 gram scratch lines remained. This was the first time this occurred during the course of this work. Upon careful observation it was noticed that the applicator was applying compound immediately after the buff passed over the 650-gram scratch line and just before it made contact with the 850-gram scratch line. This again demon-

TABLE XV
BUFFING TEST USING AUTOMATIC APPLICATOR SINGLE LEAD SCREW

Pounds Pressure	Surface Feet per Minute		
	4500	5500	6500
	Gram Scratch Lines Removed		
19	400	150	200
25	400	400	400
31	700	500	500

TABLE XVI
BUFFING TEST USING AUTOMATIC APPLICATOR DOUBLE LEAD SCREW

Pounds Pressure	Surface Feet per Minute		
	4500	5500	6500
	Gram Scratch Lines Removed		
19	350	300	150
25	850	700	700
31	850	850	850

strated that the compound does the buffing and its proper application is most important.

SUMMARY

1. The optimum speed for the buffing of zinc die castings for the most efficient line removal lies between 4000 and 5000 SFPM regardless of the pressure, the amount of compound applied, or type of bias, ventilated buff employed.
2. Increasing the pressure increases the rate of line removal up to a certain optimum point. This level must be determined for each specific job.
3. The rate of compound application is perhaps the most important single factor in the entire operation. The use of more compound results in more line removal up to a certain level; however, compound can be used more efficiently by applying smaller amounts at regular, frequent intervals. Substantial savings in compound should result from the use of an automatic applicator both in hand and automatic buffing.
4. The automatic applicators studied are not consistent in the amount of compound that is removed from the bar. In spite of faults, their use results in a more uniform operation than that obtained manually.
5. For every set of conditions (wheel pressure, SFPM, amount and rate of compound delivery) a certain maximum temperature is attained. The optimum conditions for line removal (high wheel pressure, 4000–5000 SFPM, and more compound) result in the highest temperatures attained.

ACKNOWLEDGMENT

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William Geissman received his BS in Chemical Engineering from Marquette University in 1934. Subsequently he was Chemical Engineer at Briggs and Stratton Corporation until 1942 when he was employed by the Allis Chalmers Corporation until 1947. After two years with the S. K. Williams Company, he took the position of Assistant Superintendent of Finishing at National Lock Company. He is a member of the AES and Committee B-8 of ASTM. In 1952, along with Robert Carlson, he was awarded the AES Carl Heussner award.

R. Scott Modjeska received his degree in chemical engineering from Illinois Institute of Technology. He did graduate work in chemistry at De Paul University and University of Chicago. He has taught applied electrochemistry at IIT and inorganic chemistry at De Paul.

Mr. Modjeska has been associated with Scientific Control Laboratories, Inc. since 1938, doing both consulting and research. His previous connections include Nickel Chromium Corporation, Stewart Warner Corporation, Apollo Metal Works and B. Mercil & Sons Plating Company.

He is a member of AES, ECS, ASM, ASTM, Faraday Society and A Fellow AIC. He is a Registered Professional Engineer, State of Illinois, and author of numerous technical articles.

Kenneth Gatchel attended Marquette University and Beloit College majoring in Chemistry and Physics. He has been associated with National Lock Company for the past five years as a laboratory technician. Mr. Gatchel is a member of the American Chemical Society, the American Physics Institute (AAPT), The American Association for the Advancement of Science, and the American Electroplaters' Society.

GLOSSARY

ABRASIVE: Substance used to abrade metals. The material is crushed and sieved to different degrees of fineness and made suitable for different degrees of finishing. There are two classes of abrasives: manufactured and natural. Aluminum oxide and silicon carbide, manufactured abrasives, are used for metal polishing as are the naturally occurring American, Turkish or Naxos emery. These abrasives are then cemented or glued to wheels or belts for use. Tripoli, amorphous silica, crystalline silica, Vienna lime, aluminum oxides, rouge, emery, and pumice are the most widely used abrasives in buffing compounds.

ALUMINUM OXIDE ABRASIVES: Both fused and unfused aluminum oxide abrasives are used in buffing compound formulations. The hard fused abrasives are used to produce greaseless compounds. The unfused abrasives are carefully graded by screening, water floating or air separating and are then suitable, as is fused aluminum oxide, for bar and liquid buffing compound use. These abrasives are used for cutting down and coloring hard metals such as carbon steel, stainless steel, and chromium.

AMORPHOUS SILICA: Chemically and physically similar to Tripoli but softer and finer in grain size and not as absorbent. Being free of iron it is white in color. Used on the lighter cutting down buffing operations or on secondary color buffing operations after the use of Tripoli compound. These compounds are sometimes called "white coloring compounds."

AUTOMATIC APPLICATOR: A device that applies buffing compound against the wheel at a predetermined rate.

AUTOMATIC BUFFING MACHINE: A piece of equipment designed

so that parts may pass under one or more buffing heads after being placed on suitable fixtures and thus receive the necessary work so that the part will be buffed.

BACK STAND: A free running, adjustable idler pulley mounted in the rear of the lathe and used to support the polishing belt.

BIAS BUFF: Type of buff having a rigid center of metal or plastic composition, constructed of rectangular strips of cloth cut on the bias and fastened to the rigid center and the pleats or folds forming puckered pockets. The layers of cloth are on the same plane as the rigid center. A buff, generally designated as a No. 1 wheel, is made of strips of cloth equal in length to the circumference of a wheel whose diameter is equal to that of the final wheel plus one inch. A No. 2 wheel is made of strips of cloth equal in length to the circumference of a wheel whose diameter is equal to that of the final wheel plus two inches, and so on up to the No. 10 wheel when strips of cloth equal in length to the circumference of a wheel whose diameter is equal to that of the final wheel plus ten inches, are used. This variation in the amount of cloth used serves to produce buffs of varying densities.

BINDER: Materials used as a carrier for the abrasive in a compound whether bar or liquid. These can be mixtures of tallows, fatty acids, hydrogenated fish oil, hydrogenated fatty acids, hydrocarbons, waxes, and other organic compounds.

BOB: A short stub polishing or buffing wheel with a rounded end, used for buffing and polishing the interior of hollowware or other similar parts. These wheels are made of felt, leather, or cloth such as muslin.

BUFF DESIGNATIONS: Bias buffs are designated in this generally accepted standard manner—14 in. diameter by 5 in. centerplate, No. 2 (amount of cloth—see bias buff), 16 ply, 86/92 cloth count, 2.50 cloth weight, with 1.25 in. diam. arbor hole center. This is shortened to 14 by 5 in., No. 2, 16 ply, 86/92, 2.50 yd, with 1.25 arbor hole.

BUFF SEWINGS: Design of stitching used to hold a full disc, pieced, or folded buff together. Buffs may be sewed concentrically, radially square sewed, spirally, or even combinations of the above.

BUFFING: The production of smooth, bright, reflective, scratch free surfaces by means of revolving flexible buffs "charged" with buffing compound in contact with the work.

BUFFING COMPOUND: A liquid or solid mixture of abrasive and suitable vehicle or binder used on the buff to effect a desired surface condition.

BUFFING HEAD: A piece of machinery, usually part of an automatic buffing machine, having a motor driving a spindle capable of carrying a number of buff sections. The spindle is arranged so that it can be held at any given angle.

BUFFING LATHE: A piece of machinery having a motor driving either one or two spindles at either constant or at variable speeds. These spindles are arranged in a horizontal position and have suitable threads, flanges and nuts so that wheels can be easily put on and removed.

BUTLER FINISHING: A fine, and light polishing operation that uses a fine grit as a paste or a greaseless compound on a loose wheel rotating at about 5500 SFPM. This imparts the final finish to parts plated with chrome, brass, bronze, nickel, zinc, and silver or parts made of solid materials such as aluminum, stainless steel, and sterling silver.

CANTON FLANNEL BUFF: Each ply is a full circular disc of cotton flannel, one face of which is heavily combed cotton which produces a very soft face.

CLOSE FACE BUFF: Type of bias buff in which the strips fastened to the rigid center plate are two ply; this is accomplished by folding the strip and fastening the fold to the center.

COLOR: The luster produced by buffing.

COLOR BUFFING: A second buffing operation prior to plating. Sometimes a milder compound and softer wheel are used to remove the wheel marks from hard buffing operation. Also a luster-producing buffing step on high quality stock or on plated surfaces. The work travels with the direction of rotation of the wheel.

CONTACT WHEEL: A wheel of canvas cloth, leather, felt, rubber, combined cloth and rubber and cork all in suitable densities, with plain or serrated faces, mounted on the lathe spindle supporting the working area of the polishing belt.

CROCUS: A purple colored, coarse grade of rouge almost obsolete but still used to some extent for buffing cutlery and some nonferrous metals.

CROSS-BUFF: Buffing at some angle to the direction of the polishing lines, usually at a 45° angle or more if possible.

CRYSTALLINE SILICA: Flint, agate, and quartz are hard, sharp and crystalline in structure. The cutting action is sharp but short lived because the cutting edges wear round rather than breaking down to present fresh cutting surfaces. Has low grease absorption ability and makes a poor abrasive for buffing compounds. It is useful for burring operations where a sharper cut is desired and the binder characteristics can be sacrificed.

CUT: The removing of surface imperfections. It is sometimes said that a wheel or compound has good "cut."

CUT AND COLOR COMPOUND: Combination blend of amorphous silica and Tripoli mixed with grease binders, sometimes called "Double Duty."

CUTTING DOWN: A preliminary step performed with a sharp or fast cutting compound to smooth the surface and bring up as bright a finish with one buffing operation. The work travels against the direction of rotation of the wheel.

DRAG: Producing grooves by over buffing areas around holes and other depressions.

DRY FINE: A polishing operation which uses finer grits (280 and 320 grit) but without oiling.

DULL BRUSH: See satin finish.

FACE: The outside edge or periphery of the wheel.

FANNING: Buffing the work very lightly to bring up the luster. The work traveling with the direction of rotation of the wheel, very similar to "wiping."

FOLDED BUFFS: Assembled from single plies of cloth that have been folded over two or three times to form quarters or eighths of a circle. The wedge-shaped pieces are dispersed evenly between two full discs and often spirally sewed from the arbor hole to the periphery, but sometimes the sewing is far in from the periphery.

FULL DISC BUFF: Each ply of muslin composing a section is a full circular disc, and all discs in a section are held together by one circular stitching at the arbor hole for loose buffs. Sewed buffs can be sewed to the periphery spirally or concentrically with a desired spacing between the rows.

GLAZE: (1) The abraded metal, worn polishing grains and other debris adhering between the unused polishing grains on a belt or polishing wheel; (2) The abraded metal, the used buffing compound, the used buff, and other debris that accumulates on the face of the buff.

GREASELESS COMPOUND: A compound containing an abrasive or mixture of abrasives in a glue-water gel binder. When applied to a revolving wheel, sufficient heat is generated by friction to cause the compound to melt and be transferred to the wheel, and almost immediately it sets up to form a dry, abrasive coated wheel.

GREASE WHEEL: Polishing operation using grease stick or oil on the face of the wheel to produce a finer polish than that obtained in dry polishing.

HEAD: The compound and/or abrasive attached to the face of the wheel.

HIGHLIGHTING: Buffing oxidized or sulfided parts to remove the oxide or sulfide to provide a lustrous finish to the highlights that contrast to the colored article.

LEAVE-OFF: An abraded appearance on the buffed surface where the wheel leaves the work. This streak is accentuated by the presence of grease from the binder in the buffing compound.

LIME COMPOUND: Made by blending Vienna Lime with moisture-free grease binders. This compound must be kept from moisture-laden air, since calcium hydroxide will begin to form, and will react with the fatty acids in the grease binders. A

slaking action takes place, causing the compound to crumble and disintegrate, making it useless for buffing purposes. It is also known as White Finish or Nickel Buffing Compound. It is especially used for nickel buffing and also used for brass, copper-plate, and the softer plates of cadmium, tin, and zinc.

NUBBINS: Ends of bar compound that are too short to be of further use, sometimes melted for re-use.

OILING: Lubricating a polishing belt or wheel with materials such as kerosene, oil, grease stick, or tallow. Usually used to help remove the coarser lines produced in dry polishing.

OPEN FACE BUFF: Type of bias buff in which the strips fastened to the rigid center plate are single ply.

PIECED BUFF: Clippings of odd shaped pieces of various grades and types of fabrics are held between full disc cover sheets of muslin by various methods of sewing: spiral, concentric, square ripple, tangent, radial.

PLY: The number of layers of cloth that make up the thickness of the section.

POLISH: The unreflective finish produced by the polishing operation.

POLISHING: A flexible, resilient grinding operation. The object being the removal, smoothing or levelling of surface imperfections; such as pits, scratches, parting lines, mold marks, tool and die marks and stretched metal strains.

POLISHING BELTS: Endless strips of cloth coated with suitable backing and adhesives to which carefully sized abrasives are applied under precise factory controlled conditions. Infrequently, they are set-up by the polisher.

POLISHING WHEEL: A flexible wheel usually made of a chosen number of buff sections joined together with varying degrees of rigidity. Felt, leather, and compressed canvas belts are also used. Abrasives of 80 mesh or finer are then bonded to the face of the wheel with a suitable cement or glue.

PUCKER: The folds or corrugations formed by pulling the cloth towards the center of the wheel as in the manufacture of a bias buff.

PUCKERED BUFF: See bias buff.

PUMICE: Naturally occurring complex silicates of aluminum, potassium and sodium. Sometimes powdered pumice is mixed with water for wet brushing operation on a loose sewed buff, also combined with grease binders and used on Tampico Brushes for producing "brush" finishes.

RAKING: The removing of the glaze from a wheel by applying a sharp instrument, lump pumice, or stone against the revolving wheel.

RELIEVING: Dull brushing or wire brushing oxidized or sulfided parts to remove the oxide or sulfide to provide a satin finish that contrasts to the colored article.

ROUGE: Almost pure iron oxide prepared from iron sulphate. Its color differs with the state of iron oxidation. Red Rouge is most popular, but other colors such as yellow, brown, purple and black are produced. A soft, fine red rouge bonded with a high melting point grease binder makes an excellent compound for color buffing: gold, silver and platinum.

SANDING: See Polishing.

SATIN FINISH: Similar to Butler Finish but coarser greaseless compounds may be used.

SECTION: A number of plies of cloth attached together. Thus a buff section may be described as 12 ply, 14 ply, 16 ply, etc.

SET-UP WHEEL: See Polishing Wheel.

SFPM: Surface Feet Per Minute—a term used to designate true wheel speed determined by multiplying the revolutions per minute of the wheel by its circumference.

TRIPOLI: An abrasive, an unusual form of natural amorphous silica, absorption of iron from surface water causes variation in color from a light cream to a dark brownish red. The particles are soft, and porous with a friable structure. Its high absorption capacity for water, oil or grease makes it valuable in the abrasive field. It has the best friability for cutting down and coloring most non-ferrous metals, particularly copper, zinc die castings, stamped, cast or rolled brass and aluminum.

VIENNA LIME: Soft calcined dolomite lime that originates from limestone. Chemically, limestone is calcium and magnesium carbonate, which is converted to almost pure calcium and magnesium oxide by heating after crushing and grinding.

WET BRUSHING: Passing a piece under a wire wheel of steel or brass while water is being run onto the wheel.

"WIPING": Buffing the work with a dry cloth wheel or one lightly dressed with compound to improve the color of the buffed surface. The work travels with the direction of rotation of the wheel.

GLOSSARY OF TEXTILE TERMS PERTINENT TO BUFFS

BLEND: A yarn produced by mixing either different grades of cotton or as best understood by mixing different types of fibers. These are spun to produce a yarn having characteristics that cannot be obtained from any one fiber alone.

CLOTH WEIGHT: The total yards of cloth that will weigh one pound. The width of fabric being the full width which in the case of cotton is usually 40 inches.

COUNT: There are two definitions. Count can be a number representing the weight of a specific length of yarn as compared to a standard. In the case of cotton a singles yarn is one in which 840 yards weigh one pound. As the yarn becomes finer, the count increases. A 20's yarn would be a yarn in which 20 by 840 yards weigh one pound, these are used as yarn numbers. The more common textile definition is the number of warp ends and the number of filling ends per inch of fabric. For example, 92 by 86 would mean 92 ends and 86 picks.

DENIER: A unit of weight expressing a size of filament yarns. A one denier yarn would be such that 9000 meters weigh one gram. As the yarn gets heavier or coarser the denier size increases, which is the opposite of the count system.

END: An individual warp thread and, of course, the first or last part of a woven piece of cloth.

FILLING: Yarns that are run crosswise in the fabric from selvage to selvage, and an individual filling yarn is known as a pick.

PICK: A single strand of filling yarn carried across and interlaced through the strands of warp yarn.

SIZING: The process of coating warp yarns with a binding material which holds together the loose fibers or filaments giving strength and elongation characteristics to the yarn for weaving. In the case of cloth it coats the fibers to give character such as stiffness and smoothness, etc. Material used for sizing of cotton may be starch, wax, gelatine, gum paraffin and resins. The sizes are usually mixtures to which are added mildew proofing or antiseptic substances. The sizes are of two types—those which are to be removed after fabric is made and those which remain permanently in a fabric to give characteristics such as wash and wear or in buffs compound holding and other qualities.

STAPLE: Term used to give length of fibers that are to be used for spun yarns. This is used as index of quality or fineness. Sometimes the length of staple will determine on what system the fiber is to be spun such as Cotton or Worsted System.

TWIST: A most used and misunderstood term. It is the number of turns per inch in a thread, yarn or roving. If one is talking to a spinner, right twist and left twist is as he looks at it while he is spinning. The best understood term is "S" and "Z" twist. By "S" twist is meant the twist when the yarn is held in front of one follows around the yarn as the elongated part of the letter "S". When the "Z" yarn is held in the same way, the twist follows the elongated part of the letter "Z".

WARP: A series of yarns which run lengthwise in a fabric and are parallel to the selvage or side of fabric.

WEAVE: The characteristics produced by interlacing filling yarns with warp yarns to form the design of fabric such as plain, twill, basket, satin, etc.

WOOF: A term which appears in some books as the filling is now obsolete as a term for filling, as is the term weft for warp.

CALCULATION OF THE CURRENT DISTRIBUTION AT ELECTRODES INVOLVING SLOTS

by CARL WAGNER*

ABSTRACT

The current distribution at a cathode involving a slot is calculated for (1) negligible polarization, (2) a linear current density-potential curve, and (3) an exponential current-density polarization curve.

1. INTRODUCTORY

In conjunction with experimental investigations by Garmon and Leidheiser[1] on the current distribution during the electrodeposition of metals at cathodes involving slots, theoretical calculations are communicated. The geometry of a cathode involving a slot is shown in Fig. 1. The depth b of the slot is assumed to be much greater than its width a. The anode is supposed to be at a distance much greater than width a.

Calculations have been made for three limiting cases:

(1) No polarization occurs and, therefore, the potential in the electrolyte along the surface of the cathode is constant.

(2) The current density is a linear function of the single electrode potential.

(3) The current density depends exponentially on the single electrode potential in accord with the Tafel equation.

In all three cases, local depletion of metal ions to be discharged is assumed to be negligible owing to vigorous stirring of the electrolyte.

2. CALCULATION OF THE PRIMARY CURRENT DISTRIBUTION

If polarization is negligible, the potential in the electrolyte along the surface of the cathode is constant, e.g., equal to zero. Inside the electrolyte involving a constant electrical conductivity σ, the electrical potential φ must satisfy the Laplace equation

$$\text{div grad } \varphi = 0 \tag{1}$$

A solution of the Laplace equation satisfying the boundary condition $\varphi = 0$ along the surface of the cathode may be obtained with the help of conformal mapping. Therefrom the local current density J at the electrode is obtained in accord with Ohm's law,

$$J = \sigma \left| d\varphi/dn \right| \tag{2}$$

where $d\varphi/dn$ denotes the potential gradient in the electrolyte normal to the surface of the electrode.

The locus of any point of the x-y plane shown in Fig. 1 may be expressed in terms of the complex number

$$z = x + iy \tag{3}$$

The z-plane shown in Fig. 1 is related to the ζ-plane shown in Fig. 2 by a Schwarz-Christoffel transformation where

$$\zeta = \xi + i\eta \tag{4}$$

and ξ and η are the coordinates of the ζ-plane. According to Betz[2] the relation between z and ζ may be formulated as

$$z = \frac{a}{2E(m, 1)} \int_0^{\zeta} \left[\frac{1 - m^2 \zeta^2}{1 - \zeta^2} \right]^{1/2} d\zeta \tag{5}$$

where E(m, 1) is Legendre's standard form of the complete elliptic integral of second kind,

$$E(m, 1) = \int_0^1 \left[\frac{1 - m^2 \zeta^2}{1 - \zeta^2} \right]^{1/2} d\zeta \tag{6}$$

and the modulus m is determined by

$$\frac{1}{E(m, 1)} \int_1^{1/m} \left[\frac{1 - m^2 \zeta^2}{\zeta^2 - 1} \right]^{1/2} d\zeta = \frac{2b}{a} \tag{7}$$

Since the potential along the surface of the electrode is supposed to be zero, the boundary condition for the ζ-plane is

$$\varphi = 0 \text{ at } \eta = 0 \tag{8}$$

Hence the solution of the Laplace equation for the ζ-plane is

$$\varphi = -C \operatorname{Re} i\zeta \tag{9}$$

where Re (. . .) is the real part of the subsequent expression and C is a constant which is proportional to the current density J_0 prevailing at the surface of the electrode far away from the slot.

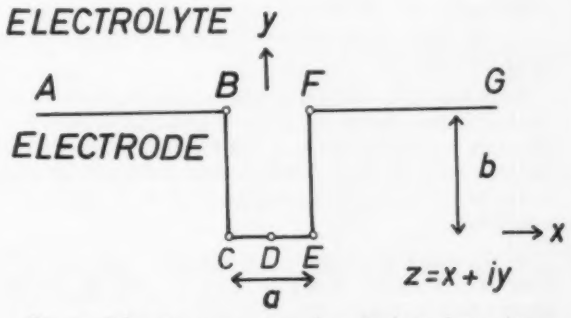

Fig. 1. Schematic cross section through electrode involving a slot for calculation of the primary current density.

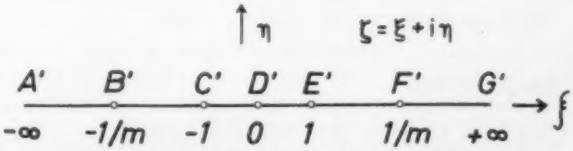

Fig. 2. Conformal mapping of z-plane shown in Fig. 1.

* Max-Planck-Institut für physikalische Chemie, Göttingen, Germany.

With the help of Eqs. (5) and (9), the potential gradient at surfaces of the electrode which are parallel to the x-axis is found to be

$$\frac{\partial \varphi}{\partial y} = -C\,\mathrm{Re}\,\frac{d(i\zeta)}{d\zeta}\,\frac{d\zeta}{dz}\,\frac{\partial z}{\partial y} \tag{10}$$

$$= \frac{2CE(m,1)}{a}\left[\frac{1-\zeta^2}{1-m^2\zeta^2}\right]^{1/2} \quad (0<\zeta^2<1 \text{ and } \frac{1}{m^2}<\zeta^2<\infty)$$

whereas the potential gradient at surfaces parallel to the y-axis is

$$\frac{\partial \varphi}{\partial x} = \pm\, C\,\mathrm{Re}\,\frac{d(iz)}{dz}\,\frac{d\zeta}{dz}\,\frac{\partial z}{\partial x}$$

$$= \pm\,\frac{2CE(m,1)}{a}\left[\frac{1-\zeta^2}{m^2\zeta^2-1}\right]^{1/2} \left(1<\zeta^2<\frac{1}{m^2}\right) \tag{11}$$

For large distances from the opening of the slot corresponding to the limiting condition $x = \infty$, $y = b$, one obtains from Eq. (10)

$$\frac{\partial \varphi}{\partial y} = \frac{2CE(m,1)}{am} \text{ if } x = \infty,\ y = b \tag{12}$$

Upon dividing through corresponding sides of Eqs. (10) or (11) and (12), one obtains the ratio of the potential gradient at a given point to the potential gradient at $x = \infty$, $y = b$, which is equal to the corresponding current density ratio J/J_0. The current densities for surfaces parallel to the x-axis and the y-axis are denoted by $J(-)$ and $J(|)$, respectively. Then it follows from Eqs. (10) to (12) that

$$\frac{J(-)}{J_0} = m\left[\frac{1-\zeta^2}{1-m^2\zeta^2}\right]^{1/2} = m\left[\frac{\zeta^2-1}{m^2\zeta^2-1}\right]^{1/2} \tag{13}$$

$$\frac{J(|)}{J_0} = m\left[\frac{\zeta^2-1}{1-m^2\zeta^2}\right]^{1/2} \tag{14}$$

where values of ζ are related to values of the coordinates x and y by virtue of Eq. (5) and J_0 is the current density far away from the slot.

From Eqs. (13) and (14) it follows that the local current density at the edge of the slot corresponding to point F in Fig. 1 ($x = a/2$, $y = b$, i.e., $\zeta = 1/m$) tends to infinity. On the other hand, the local current density vanishes at the inner corner of the slot corresponding to point E in Fig. 1 ($x = a/2$, $y = 0$, i.e., $\zeta = 1$).

At the center of the bottom of the slot corresponding to point D in Fig. 1 ($x = 0$, $y = 0$, i.e., $\zeta = 0$), the current density ratio is found to be

$$J(-)/J_0 = m \quad \text{at } x = 0,\ y = 0 \tag{15}$$

The value of the modulus m is to be calculated from Eq. (7). Upon introducing the auxiliary variable

$$u = m\,\mathrm{Re}\,\zeta = m\,\xi \tag{16}$$

Eq. (7) becomes

$$\frac{1}{E(m,1)}\int_m^1\left[\frac{1-u^2}{u^2-m^2}\right]^{1/2} du = \frac{2b}{a} \tag{17}$$

If $m \ll 1$, one may introduce an auxiliary constant value m^* which satisfies the condition

$$m \ll m^* \ll 1 \tag{18}$$

Hence the integral in Eq. (17) is found to be

$$\int_m^1\left[\frac{1-u^2}{u^2-m^2}\right]^{1/2} du \cong \int_m^{m^*}\left[\frac{1}{u^2-m^2}\right]^{1/2} du + \int_{m^*}^1\left[1-u^2\right]^{1/2}\frac{du}{u}$$

$$= \ln\frac{m^* + (m^{*2}-m^2)^{1/2}}{m} - \left[(1-m^{*2})^{1/2} + \ln\frac{1-(1-m^{*2})^{1/2}}{m^*}\right]$$

$$\cong \ln\frac{2m^*}{m} - \left[1 + \ln\frac{1-(1-m^{*2}/2)}{m^*}\right]$$

$$\cong -\,[1 + \ln(m/4)] \text{ if } m \ll 1,\ m^* \ll 1 \tag{19}$$

Moreover, if $m \ll 1$, Eq. (6) becomes

$$E(m,1) \cong E(0,1) = \pi/2 \tag{20}$$

Upon substituting Eqs. (19) and (20) in Eq. (17) and solving for m, it follows that

$$m = 4\exp\left[-\left(1+\frac{\pi b}{a}\right)\right]$$

$$\text{if } m \ll 1, \text{ i.e., } 2b/a \gg 1 \tag{21}$$

In what follows, the case of a narrow slot corresponding to Eq. (21) is considered. From a practical point of view, Eq. (14) for the current density at the lateral faces inside the slot is especially important. Substituting $u = m\zeta$ in Eq. (14) and letting $m = 0$, one has

$$\frac{J(|)}{J_0} = \frac{u}{(1-u^2)^{1/2}} \tag{22}$$

Writing Eq. (5) for point F with the coordinate $z = a/2 + ib$ corresponding to $\zeta = 1/m$, subtracting corresponding sides from Eq. (5) for $z = a/2 + iy$, and multiplying through by $-i$, one has

$$y' = b - y = \frac{a}{2E(m,1)}\int_\zeta^1\left[\frac{1-m^2\zeta^2}{\zeta^2-1}\right]^{1/2} d\zeta \tag{23}$$

where y' is the distance from the opening of the slot.

For the limiting case $m \to 0$, Eq. (23) becomes on substituting Eqs. (16) and (20)

$$y' = \frac{a}{\pi}\int_u^1\left[(1-u^2)^{1/2}/u\right] du \tag{24}$$

Integration yields

$$y' = \frac{a}{\pi}\left[\ln\frac{u}{1-(1-u^2)^{1/2}} - (1-u^2)^{1/2}\right] \tag{25}$$

With the help of Eq. (25), one may plot u vs. y'. From this plot one may read values of u for given distances y'. Then one may calculate relative current densities with the help of Eq. (22). A graph of $J(|)/J_0 = J(y')/J_0$ as a function of y'/a is shown in Fig. 3. Inspection of Fig. 3 shows that

the current density at the lateral faces of the slot decreases sharply when the distance y' from the opening of the slot exceeds its width a.

For small values of u, it follows from Eq. (25) that

$$y' \cong \frac{a}{\pi}\left[\ln \frac{u}{1-(1-u^2/2)} - 1\right] = (a/\pi)\,[-1 - \ln (u/2)] \tag{26}$$

Solving Eq (26) for u, one has

$$u = 2 \exp\,[-(1 + \pi\, y'/a)] \quad \text{if } u \ll 1, \text{ i.e., } y' \gg a/\pi \text{ and } x = a/2 \tag{27}$$

Substitution of Eq. (27) in Eq. (22) for $u \ll 1$ yields

$$\frac{J(|)}{J_0} \cong u \cong 2 \exp\left[-(1 + \pi\, y'/a)\right] \quad \text{if } y' \gg a/\pi \tag{28}$$

corresponding to an exponential decrease of the current density J(|) if the distance y' from the opening of the slot is much greater than width a.

A pronounced decrease of the primary current density at faces inside a narrow slot with increasing distance from the opening of the slot as calculated in Eq. (28) is in accord with qualitative reasoning. It seems surprising, however, that the decrease is so sharp as is shown in Fig. 3.

3. CALCULATION OF THE SECONDARY CURRENT DISTRIBUTION IN A NARROW SLOT

Polarization results in a more uniform current distribution. The secondary current density at the surface inside a slot

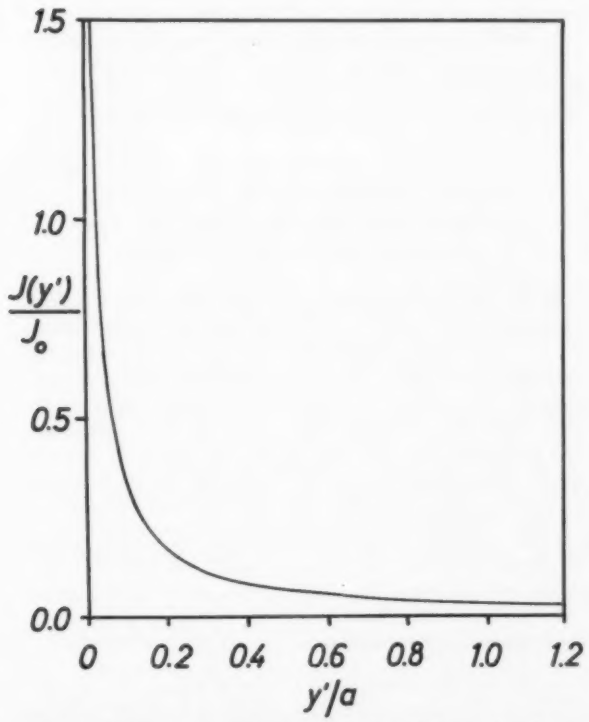

Fig. 3. Primary current density at the lateral faces of a slot according to Eqs. (22) and (25).

may, therefore, be significantly higher than the primary current density.

Inside the slot shown in Fig. 1 the current flows mainly in the y-direction. Thus, disregarding a dependence of the potential on x, one has according to Ohm's law

$$I_y \cong ac\,\sigma\,(d\,\varphi/dy) \tag{29}$$

where I_y is the strength of the current in the negative y-direction and c is the breadth of the slot perpendicular to the x-y plane shown in Fig. 1.

Since the current lines end at the lateral faces of the slot, the current I_y increases from the bottom toward the opening of the slot. The rate of change is

$$dI_y/dy = 2\,cJ(y) \tag{30}$$

where $J(y) = J(|)$ is the current density at the lateral faces of the slot at distance y from the bottom.

In view of the high electrical conductivity of all metals, the potential inside the electrode is virtually constant. Thus the local single electrode potential E_e increases as the potential φ in the electrolyte decreases. Hence the boundary condition for the potential φ next to the surface of the electrode is

$$\varphi = \text{constant} - E_e \tag{31}$$

Since E_e is a function of the local current density J(y), the following calculations depend on the relation between E_e and J.

(1) If the polarization curve is linear, $dE_e/dJ = -\,|\,dE_e/dJ\,|$ is independent of J. Thus it follows from Eq. (31) that

$$\frac{d\varphi}{dy} = \left|\frac{dE_e}{dJ}\right| \frac{dJ}{dy} \tag{32}$$

Substitution of Eqs. (29) and (32) in Eq. (30) with $y' = b - y$ yields

$$\frac{d^2J}{(dy')^2} = \frac{2J}{a\,\sigma\,|\,dE_e/dJ\,|} = \frac{2J}{ak_e} \tag{33}$$

where

$$k_e = \sigma\,|\,dE_e/dJ\,| \tag{34}$$

is the so-called polarization parameter[3].

The general solution of Eq. (33) reads

$$J(y) = C_1 \exp\,[y'/(ak_e/2)^{1/2}] + C_2 \exp\,[-\,y'/(ak_e/2)^{1/2}] \tag{35}$$

where C_1 and C_2 are constants. If the slot is sufficiently deep, the current density $J(y' = b)$ at the bottom of the slot is negligible in comparison to that at the opening of the slot, $J(y' = 0)$. Under these conditions the first term on the right-hand side of Eq. (35) must vanish. Thus Eq. (35) becomes

$$J(y') \cong C_2 \exp\,[-\,y'/(ak_e/2)^{1/2}] \quad \text{if } b \gg (ak_e/2)^{1/2} \tag{36}$$

where the latter condition is formulated in accord with the presupposition that

$$J(y' = b) \ll J(y' = 0) \tag{37}$$

Eq. (36) is based on Eq. (29) which implies that inside the slot the dependence of the potential φ on the coordinate x can be ignored for the sake of an approximation. Therefore Eq. (36) cannot be applied to the vicinity of the opening of the slot without special provisions. If $a \ll (ak_e/2)^{1/2}$, i.e., $(k_e/a)^{1/2} \gg 1$, it follows from Eq. (36) that the current density J varies significantly only over distances which are much greater than the width a. Under these conditions Eq.

(36) may be assumed to hold approximately also at $y' = 0$. Hence

$$J(y') \cong J_{edge} \exp\left[-y'/(ak_c/2)^{1/2}\right] \quad \text{if } (k_c/a)^{1/2} \gg 1,\ b \gg (ak_c/2)^{1/2} \tag{38}$$

where $J_{edge} = J(y' = 0)$ is the current density at the edge of the slot.

(2) If activation polarization prevails and the single electrode potential of the cathode is sufficiently less noble than the equilibrium potential, a Tafel equation may be expected to represent the relation between E_e and J,

$$E_e = \text{constant} - \frac{RT}{\alpha_c zF} \ln J \tag{39}$$

where z is the valence of the metal ions which are discharged and α_c is the transfer coefficient of the cathodic reaction.

From Eqs. (31) and (39) it follows that

$$\frac{J(y')}{J(y'^*)} = \exp\left[\frac{(\varphi - \varphi^*)\,\alpha_c\, zF}{RT}\right] \tag{40}$$

where y'^* denotes the distance of a fixed point from the opening of the slot and φ^* the corresponding potential.

Substitution of Eqs. (29) and (40) in Eq. (30) yields with $y' = y - b$

$$\frac{d^2\varphi}{(dy')^2} = \frac{2J(y'^*)}{a\,\sigma} \exp\left[\frac{(\varphi - \varphi^*)\,\alpha_c\, zF}{RT}\right] \tag{41}$$

Eq. (41) may be rewritten as

$$\frac{d}{d\varphi}\left[\left(\frac{d\varphi}{dy'}\right)^2\right] = \frac{4J(y'^*)}{a\,\sigma} \exp\left[\frac{(\varphi - \varphi^*)\,\alpha_c\, zF}{RT}\right] \tag{42}$$

Multiplying through Eq. (42) by $d\varphi$ and integrating with the condition $d\varphi/dy' = 0$ for $\varphi = -\infty$ corresponding to $J = 0$ at $y' = \infty$ after Eq. (40) for a slot of infinite depth, one obtains

$$\left(\frac{d\varphi}{dy'}\right)^2 = \frac{4J(y'^*)\,RT}{a\,\sigma\,\alpha_c\, zF} \exp\left[\frac{(\varphi - \varphi^*)\,\alpha_c\, zF}{RT}\right] \tag{43}$$

Taking the square root of Eq. (43) with the negative sign of the right-hand member in accord with the physical situation and integrating once more with $\varphi = \varphi^*$ at $y' = y'^*$ as the lower limit,

$$y' - y'^* = -\left[\frac{a\,\sigma\,RT}{\alpha_c\, zFJ(y'^*)}\right]^{1/2} \left\{\exp\left[-\frac{(\varphi - \varphi^*)\,\alpha_c\, zF}{2\,RT}\right] - 1\right\} \tag{44}$$

Substituting Eq. (40) in Eq. (44) and solving for $J(y')/J(y'^*)$, one has

$$\frac{J(y')}{J(y'^*)} = \frac{1}{\left\{1 + (y' - y'^*)\left[\frac{\alpha_c\, zFJ(y'^*)}{a\,\sigma\,RT}\right]^{1/2}\right\}^2} \tag{45}$$

Upon substitution of Eq. (39) in Eq. (34), the polarization parameter k_c is found to be

$$k_c = \frac{\sigma\,RT}{\alpha_c\, zFJ} \tag{46}$$

In view of Eq. (46), one may rewrite Eq. (45) as

$$\frac{J(y')}{J(y'^*)} = \frac{1}{\left\{1 + \frac{y' - y'}{(ak_c^*)^{1/2}}\right\}^2} \quad \text{if } b \gg (ak_c^*)^{1/2} \tag{47}$$

where k_c^* is the polarization parameter corresponding to the current density $J(y'^*)$. The condition $b \gg (ak_c^*)^{1/2}$ is formulated in accord with the assumption of a slot of virtually infinite depth which has been introduced above in order to obtain Eq. (44).

If $a \ll (ak_c^*)^{1/2}$, i.e., $(k_c^*/a)^{1/2} \gg 1$, it follows from Eq. (42) that the current density varies significantly only over distances which are much greater than the width a. Under these conditions, Eq. (47) may be assumed to hold approximately also at $y' = 0$. Hence

$$J(y') = \frac{J_{edge}}{\left\{1 + \frac{y'}{[ak_c(edge)]^{1/2}}\right\}^2} \quad \text{if } [k_c\,(edge)/a]^{1/2} \gg 1,\ b \gg [ak_c(edge)]^{1/2} \tag{48}$$

where k_c (edge) denotes the polarization parameter corresponding to the current density $J(y' = 0) = J_{edge}$.

Figure 4 shows that for a given value of k_c (edge) the current density $J(y')$ decreases with increasing distance y' less rapidly for an exponential current density-potential relation than for a linear current density-potential relation. This is in accord with qualitative reasoning. In the case of an exponential current density-potential relation, k_c is inversely proportional to J according to Eq. (46). Thus, according to general rules,[3] the "throwing power" increases with decreasing current density. This corresponds to a higher current density at a given point in the slot in comparison to another electrolyte for which the current density is essentially a linear function of the single electrode potential.

4. CALCULATION OF THE SECONDARY CURRENT DISTRIBUTION AROUND THE OPENING OF A NARROW SLOT

If in view of polarization the current density at the lateral faces of the slot decreases only slowly with increasing distance y', the number of current lines entering the opening of the slot shown in Fig. 1 exceeds substantially the number of current lines ending at a surface area of the same size far away from the slot. Crowding of current lines corresponds to a potential lower than that at remote sections of the electrode. Accordingly the current density at the outer surface next to the slot is lower than that far away from the slot.

In the case of a slot of vanishing width, the current density at the outer surface is everywhere equal to J_0 and, therefore, the potential φ equals $J_0(y - b)/\sigma$ with $\varphi\,(y = b) = 0$ at the outer surface of the electrode. If the slot has a finite width, the potential may be written as

$$\varphi\,(x, y) = J_0\,(y - b)/\sigma + \Delta\,\varphi\,(x, y) \tag{49}$$

where the additional term $\Delta\,\varphi\,(x, y)$ is the perturbation of the potential field caused by the slot.

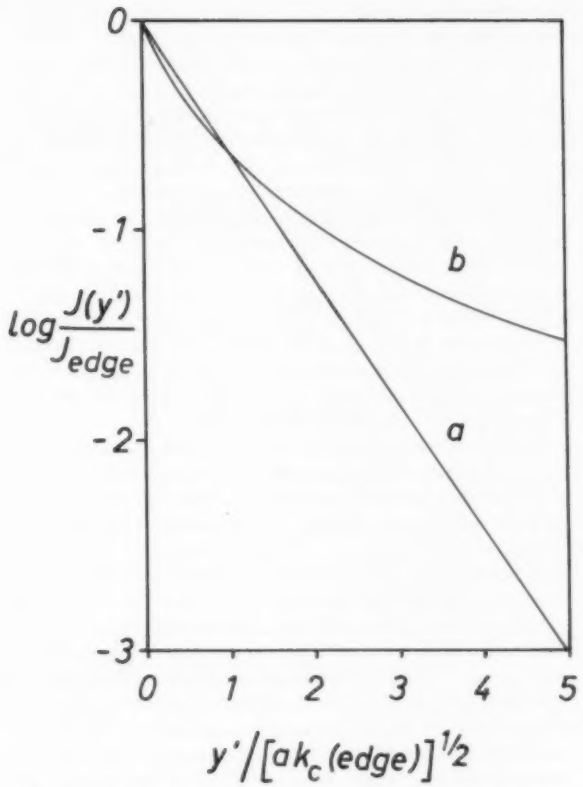

Fig. 4. Secondary current density at the lateral faces of a slot, (a) for a linear current density-potential curve according to Eq. (38), (b) for an exponential current density-potential curve according to Eq. (48).

According to Ohm's law the potential gradient in the y direction of the plane y = b equals

$$\left(\frac{\partial \varphi}{\partial y}\right)_{y=b} = \frac{J}{\sigma} \tag{50}$$

From Eqs. (49) and (50) it follows that

$$\left(\frac{\partial \Delta \varphi}{\partial y}\right)_{y=b} = \frac{J - J_0}{\sigma} \tag{51}$$

Superimposing the solutions for line sources and sinks in the plane y = b, one obtains in view of Eq. (51)

$$\Delta \varphi\,(x, y > b) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \frac{J(\alpha) - J_0}{\sigma} f(\alpha) d\alpha$$

where $f(\alpha) = \ln [(x - \alpha)^2 + (y - b)^2]$ (52)

and α is a variable of integration and $J(\alpha)$ is the current density at $x = \alpha$, $y = b$.

To obtain an approximate solution, one may assume a constant current density $J = J_{slot}$ at the opening of the slot $(-a/2 < x < a/2, y = b)$. Hence

$$\frac{\partial \Delta \varphi}{\partial y} = \frac{J_{slot} - J_0}{\sigma} \text{ at } -a/2 < x < a/2, y = b \tag{53}$$

In the case of moderate variations of the current density along the outer surface, a linear approximation for the polarization curve may be used. Thus the boundary condition on both sides of the slot becomes in view of Eqs. (31) and (34)

$$\Delta \varphi\,(x, y = b) = (J - J_0) \left| dE_c/dJ \right| = (J - J_0)\, k_c\,(\text{edge})/\sigma \text{ if } |x| > a/2 \tag{54}$$

Substitution of Eqs. (52) and (53) in Eq. (54) yields

$$\frac{1}{2\pi}\left\{ \int_{-\infty}^{-a/2} [J(\alpha) - J_0] \ln (x - \alpha)^2 d\alpha + \int_{-a/2}^{+a/2} (J_{slot} - J_0) \ln (x - \alpha)^2 d\alpha + \int_{a/2}^{\infty} [J(\alpha) - J_0] \ln (x - \alpha)^2 d\alpha \right\} = k_c(\text{edge})\,[J(x) - J_0] \text{ if } |x| > a/2 \tag{55}$$

The current density J ($|x| > a/2$), at both sides of the slot, may be calculated by solving integral equation (55) with the help of numerical methods. To obtain an approximate value of J_{edge} it is sufficient to approximate $J(|x| > a/2) - J_0$ by an appropriately chosen function which satisfies the following conditions. The function $J(|x| > a/2) - J_0$ is supposed to be negative, to have its highest absolute value at $|x| = a/2$, and to tend to zero at large values of $|x|$. Moreover, the absolute value of the integral of $J(x) - J_0$ with respect to x between $x = a/2$ and $x = \infty$ must be equal to the integral of $J_{slot} - J_0$ with respect to x between $x = 0$ and $x = a/2$ so that the excess current entering the slot is compensated by a current deficit at the outer surface of the electrode in the vicinity of the slot. The foregoing conditions are satisfied by letting

$$J(x) = J_0 - (J_{slot} - J_0) \frac{3\left(\lambda - \frac{|x|}{a/2}\right)^2}{(\lambda - 1)^3}$$

$$\text{at } a/2 < |x| < \lambda\,(a/2) \tag{56a}$$

$$J(x) = J_0 \text{ at } |x| > \lambda\,(a/2) \tag{56b}$$

where λ is an auxiliary parameter whose calculation is discussed below.

Upon substituting Eq. (38) or (48) in Eq. (30), integrating over the whole depth of the slot, and dividing by the cross section ac of the slot, one obtains the density of the current lines entering the slot, viz.,

(a) for a linear polarization curve

$$J_{slot} = (2\,k_c/a)^{1/2}\, J_{edge} \text{ if } (k_c/a)^{1/2} \gg 1,\ b \gg (a k_c/2)^{1/2} \tag{57}$$

(b) for an exponential polarization curve

$$J_{slot} = 2\,[k_c(\text{edge})/a]^{1/2}\, J_{edge} \text{ if } [k_c(\text{edge})/a]^{1/2} \gg 1,\ b \gg [a k_c(\text{edge})]^{1/2} \tag{58}$$

Upon substituting Eq. (56a), (56b) and (57) or (58) in Eq. (55) for $x = a/2$, one obtains an equation from which one may calculate values of the parameter λ for appropriately chosen values of $k_c(\text{edge})/a$ and subsequently values of $J_{edge}/J_0 = J(x = a/2)/J_0$ from Eq. (56a).

(1) In the case of a linear current density-potential curve, the polarization parameter k_c defined by Eq. (34) is independent of current density. Thus, the polarization parameter k_c^0 pertaining to the current density J_0 equals k_c

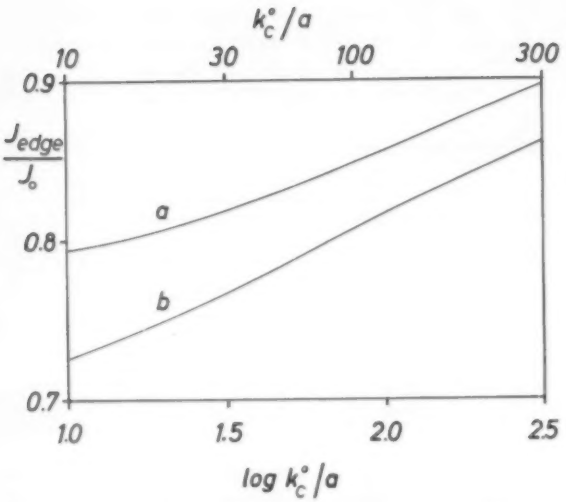

Fig. 5. Ratio of the current density J_{edge} at the outer edge of a slot to the current density J_0 according to Eqs. (55) to (60), (a) for a linear current density-potential curve, (b) for an exponential current density-potential curve.

(edge). Fig. 5, curve a, shows the corresponding plot J_{edge}/J_0 vs. $k_c^\circ/a = k_c\,(edge)/a$.

(2) In the case of an exponential current density-potential curve, one has in view of Eqs. (34) and (39)

$$\frac{k_c\,(edge)}{k_c^\circ} = \frac{J_0}{J_{edge}} \tag{59}$$

and, therefore,

$$\frac{k_c^\circ}{a} = \frac{k_c\,(edge)}{a}\,\frac{J_{edge}}{J_0} \tag{60}$$

A plot J_{edge}/J_0 vs. k_c°/a for the latter case is shown in Fig. 5, curve b.

In view of Eq. (59), one may rewrite Eq. (48) as

$$\frac{J\,(y')}{J_0} = \frac{J_{edge}/J_0}{\left\{1 + \frac{y'}{[ak_c^\circ]^{1/2}}\left[\frac{J_{edge}}{J_0}\right]^{1/2}\right\}^2} \tag{61}$$

if $(k_c^\circ/a)^{1/2} \gg 1$, $b \gg (ak_c^\circ)^{1/2}$

where values of J_{edge}/J_0 are a function of k_c°/a and may be read from Fig. 5, curve b.

The validity range of the calculations, however, is rather limited in view of the restricting conditions in Eqs. (57) and (58) according to which the square root of the ratio of the polarization parameter to width a must be much greater than unity. Thus a plot of J_{edge}/J_0 vs. k_c°/a based on the evaluation of Eqs. (55) to (58) can be regarded only as a semi-quantitative representation unless the polarization parameter k_c° is at least 100 times greater than the width of the slot.

5. CONCLUDING REMARKS

The foregoing calculations elucidate the significance of the various factors which determine the secondary current distribution. Moreover, they give pertinent information regarding the order of magnitude of the non-uniformity of the current density at electrodes involving a slot. The accuracy of these calculations, however, is limited owing to the use of approximations. The curves in Fig. 4 and 5 show, therefore, only the general trend of the current distribution. Accurate values may be computed by solving the Laplace equation (1) for the boundary conditions as determined by the current density-potential curve by using suitable numerical or graphical methods without special approximations, e.g., the relaxation method due to Southwell[4, 5] as has been suggested recently by Lynn and Tobias.[6] Approximate data obtained above may be used for starting such calculations.

The general character of the solution may be anticipated with the help of dimensional analysis. It follows that the current density ratio $J(y')/J_0$ may be written as a function of three dimensionless length ratios, viz., $y'/(ak_c)^{1/2}$, $b/(ak_c)^{1/2}$, $(k_c/a)^{1/2}$ where k_c is the polarization parameter corresponding to the current density J_0 at the outer surface of the electrode at a large distance from the slot and the explicit form of the function $J(y')/J_0$ depends on whether the current density-potential curve is linear or exponential.

Even precisely calculated current distributions, however, have a limited practical significance. In general, there will be differences between calculated values and experimental data because the conditions of laboratory experiments or industrial practice are not in accord with the various presuppositions underlying theoretical calculations such as the absence of significant concentration polarization, a constant current efficiency of metal deposition, and the absence of local variations of the polarization parameter due to the occurrence of different crystallographic faces. To obtain a complete agreement between calculated values and experimental data, it would be necessary to have a much more detailed knowledge of the actual conditions prevailing at the electrode-electrolyte interface in each particular experiment. Since this information is not readily obtainable, the significance of precise calculations is questionable. For this reason, the above calculations have not been improved by using more sophisticated mathematical methods.

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Carl Wagner was born at Leipzig, Germany, in 1901. He received a PhD degree from the University of Leipzig in 1924, taught at the Universities of Jena and Hamburg and at the Technische Hochschule of Darmstadt in Germany from 1928 to 1945, was a scientific advisor at the Ordnance Research Development Division Suboffice (Rocket), Fort Bliss, Texas, from 1945 to 1949, and joined MIT in 1949 where he was appointed professor of metallurgy in 1955. Since 1958 he is head of the Max-Planck-Institut für physikalische Chemie at Göttingen, Germany. He was awarded the Palladium Medal of the Electrochemical Society in 1952.

STUDIES OF THE ELECTRODEPOSITION OF METALS IN NARROW CREVICES

by LUCILLE B. GARMON and HENRY LEIDHEISER JR.*

INTRODUCTION

IT HAS BEEN RECOGNIZED for many years that the thickness distribution of an electrodeposit is a function of the absolute size of the cathode profile. An earlier paper[1] reviewed the experimental evidence for unusual throwing power on small-scale recesses[2, 3, 4, 5, 6, 7, 8]** and the various theories which have been proposed to account for this phenomenon.[4, 7, 8, 9] It is generally agreed that sufficiently small-scale recesses differ from large-scale recesses of the same shape in three respects: (1) From many baths, deposits on small-scale recesses, in contrast to those on large-scale recesses, are practically uniform in thickness over the profile. (2) The relative throwing power of baths, such as the cyanide copper and chromium baths, changes as the absolute size of the recess is sufficiently reduced. (3) Leveling takes place only over small-scale recesses. Although these observations were at first thought to be inconsistent with polarization theory, the behavior on microrecesses was later shown to be understandable.[8, 9, 10]

This paper, which represents the final report on AES Project No. 17, gives additional experimental data[11] on a crevice of a type which has not been studied by other investigators; i.e., one whose width is in the micro range but whose depth is in the macro range. The data are interpreted with special reference to a paper by Wagner[12] which appears in this same issue. Both primary and secondary current distribution within the crevice are treated.

EXPERIMENTAL

Cathode. The cathode used in these studies consisted of 5 cylinders, 3.2 cm (1.25 in.) in diameter and 1.3 cm (0.5 in.) high, mounted on a rod (Fig. 1). The two end cylinders were made of Lucite and served to prevent deposition on the ends of cylinders 2 and 4. The three cylinders in the center were made of copper or silver depending upon the metal being deposited. The bottom Lucite cylinder was cemented to the rod, the three metal cylinders fit snugly on the rod, and the top plastic cylinder was threaded on the rod in order to maintain rigidity. The spacings between cylinders 2 and 3 and between 3 and 4 were controlled by means of copper or brass foils, 1.6 cm (0.62 in.) in diameter, with a hole in the center for mounting on the rod. The components of the cathode were cleaned separately and were assembled beneath the surface of the plating bath in order to prevent entrapment of air in the crevices between the cylinders. The standard crevice used in the majority of experiments was 0.012 cm (0.005 in.) in width and 0.8 cm (0.3 in.) in depth.

Arrangement of Plating Cell and Control of Experimental Variables. During plating, the cathode was supported vertically in the center of a 400 or 600 ml beaker. The anode was placed adjoining the inside circumference of the

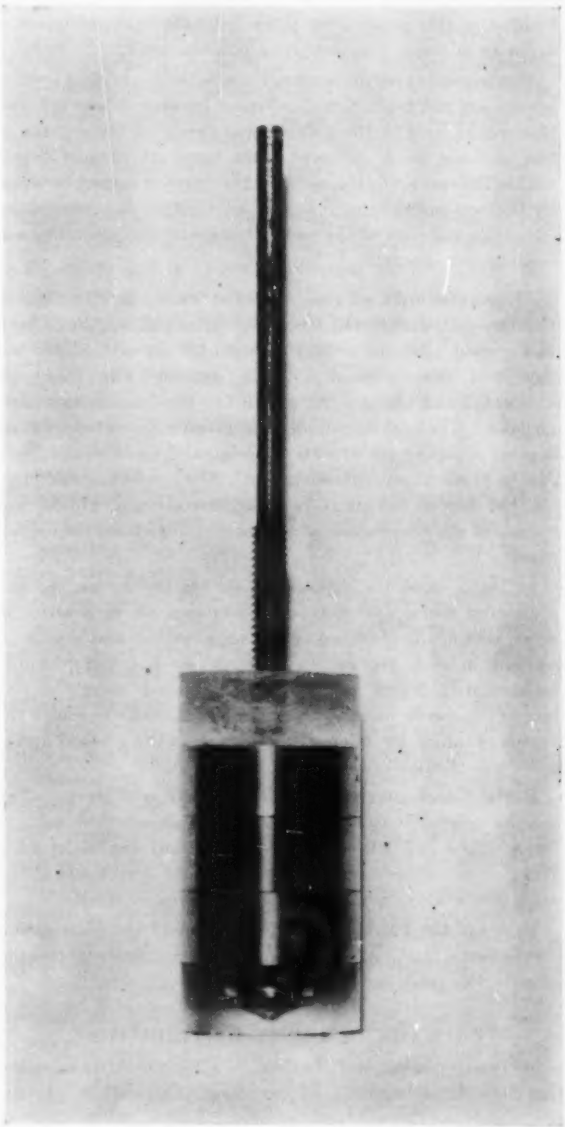

Fig. 1. The experimental cathode.

*Virginia Institute for Scientific Research, Richmond, Virginia.

**The use of the terms "small-scale recess" and "microrecess" refers to any recess whose characteristic dimension is less than Wagner's k_c. The expression "microthrowing power" is taken to mean the deposit distribution over a microrecess.

beaker and consisted of either nickel sheet or Nivac brand nickel rods when nickel was the metal being deposited, and of copper sheet when copper was the metal being deposited.

The beaker containing the electrolyte was placed in a heated water bath whose temperature was thermostatically controlled. A 6-volt battery served as the power source. Calculations of current density took into account only the exterior area of the cylindrical cathode. The *p*H of the nickel baths was checked electrometrically before every experiment and often at the end of the experiment.

Plating Baths and Conditions. The compositions of the nickel and copper baths used in the study are summarized in Table I. The results of 42 experiments were subjected to quantitative analysis. Table II shows the deposition conditions and other data pertinent to these runs. All nickel depositions were made at the "standard conditions" of this study: 60C, *p*H 4, current density and time of plating such that 1.0 amp-hr/dm² was applied to the outer surface of the cathode. These conditions yielded a standard thickness of 0.0012 cm (0.0005 in.) on the cathode exterior. All runs treated in this paper were made with moderate agitation in order to minimize concentration polarization.

Experimental results with plating baths containing leveling agents are not treated in this report because it was felt that this would lead to the polarization curve on the exterior of the cathode being different from those at various depths within the crevice as the result of the varying surface coverage by the leveling agent. It is well known that the polarization curve is a function of the concentration of many leveling and brightening agents.[13]

Measurements of the Amount and Distribution of the Deposit within the Crevice. After plating, the cathode was rinsed and dried and the actual crevice width was measured microscopically. The cathode was then disassembled and the deposit within the crevice was examined visually. The middle cylinder was given a protective electrodeposit of copper (or silver if the original deposit was copper), cast in plastic, and cross-sectioned. After polishing and etching, the deposit thickness on the cross-sectioned cylinder was measured microscopically at known distances from the crevice mouth.

In many cases the deposit within the crevice on the two remaining metal cylinders was machined off in a series of rings, chemically removed from the substrate, and the metal content in each section was determined polarographically. In several instances, interferometric methods were also employed on one or more of the cylinders in order to check the values obtained by microscopic measurement. Good agreement was obtained between the two methods.

Bath Conductivity and Polarization Curve. The specific conductivity of each bath was determined using a conductance cell with platinized platinum electrodes in a Wheatstone bridge circuit. Measurements were made at the same temperature and *p*H as used in the experiments.

Values of the Tafel slope b were obtained from polarization curves found in the literature for baths of comparable composition. The references have been cited previously.[11]

PRIMARY CURRENT DISTRIBUTION

"Primary current distribution" is a term used to describe the theoretical situation of vanishing polarization. It depends only on the electrode geometry and is independent of such factors as bath characteristics, plating conditions, and absolute size. Equations representing primary current distribution on a cathode of the type used in this study have been worked out by Wagner.[12] The problem in the present instance is to find the total amount and distribution of metal which would be deposited in the crevice under actual plating conditions if polarization were absent. Various approaches to the problem and the results obtained are outlined below.

First Approximation. A simple and direct attack on the problem was proposed by Kardos[14] who suggested that at primary current distribution the 0.012 cm wide crevice would receive almost as much current as any other 0.012 cm strip on the cylinder mantle. The total nickel, for example, deposited in the crevice would then have as its upper limit:

π (diam of cyl) (width of crevice) (current density) (plating time) (equiv wt of nickel) ÷ (value of Faraday), or, substituting the standard condition of 1 amp-hr/dm² (36 amp-sec/cm²),

$$= \frac{\pi \times 3.2 \text{ cm} \times 0.012 \text{ cm} \times 36 \text{ amp-sec/cm}^2 \times 29.36 \text{ g/equiv}}{96{,}500 \text{ coulombs/equiv}}$$

$$= 0.00132 \text{ g} = 1.32 \text{ mg}$$

or 0.66 mg on one internal face of the crevice.

This value serves only as a first approximation because the presence of the slot has an effect on the lines of current flow even in the absence of polarization. Just how great the effect is will be seen below.

Solution of the Laplace Equation Using Conformal Mapping. Under the conditions of primary current distribution, in which the electrical potential along the surface of the cathode must be constant, the potential distribution inside the electrolyte may be expressed with theoretical exactness by the Laplace equation.

$$\nabla^2 \phi = 0^* \qquad (1)$$

where ϕ represents the electric potential inside the electrolyte.

Two approaches to the solution of the Laplace equation have been used to find the primary current distribution in the present cell geometry, and thus to find the amount of metal which would be deposited in the crevice at zero polarization. The first is that of Wagner[12] who attacked the problem with the help of conformal mapping. Wagner derived the relationships:

$$\frac{J(|)}{J_0} = \frac{u}{(1 - u^2)^{1/2}} \qquad (22)^{**}$$

and

$$y' = \frac{a}{\pi} \int_u^1 \frac{(1 - u^2)^{1/2}}{u} \, du \qquad (24)$$

where J(|) is the current density on the interior surface of the crevice, J_0 the current density on the outer surface of the cathode, a the width of the crevice, y′ the distance from the crevice mouth as measured along the internal surface, and $u = m\zeta$, the latter being defined by Wagner's equations (4), (5), and (7). These relationships represent current density as a function of the distance from the crevice mouth along the internal surface of the crevice (points E to F in Wagner's Fig. 1 or points E′ to F′ in Wagner's Fig. 2).

The cylindrical symmetry of the actual cathode in the present case was not taken into account by Wagner. However, his equations may reasonably be applied if it is assumed that the current density becomes negligible at a distance from

*All symbols have the same meaning as in the preceding paper by Wagner.
**Equations are numbered to correspond with those in the preceding paper by Wagner.

the mouth of the crevice which is very small compared with the radius r of the cylinder. To obtain the total current I reaching the circular surface of one internal face of the actual crevice, one has then to calculate

$$I = 2\pi r \int_0^b J(\ )dy'$$

$2\pi r$ being taken as the "breadth" (circumference) of the cathode and b as the depth.

but $$dy' = \frac{-a}{\pi} \frac{(1 - u^2)^{1/2}}{u} du \qquad \text{from (24)}$$

Also, from the definition $u = m\zeta$, plus a comparison of Wagner's Figs. 1 and 2, it follows that at $y' = 0$, $u = 1$ and at $y' = b$, $u = m = 0$ ($m = 0$ being a condition imposed in deriving Eq. (22)).

Therefore,

$$I = -(2raJ_0) \int_1^0 du = 2raJ_0$$

and if the current efficiency is everywhere equal to 100 per cent

$$\text{Total metal} = \frac{(\text{total current})\,(\text{total time})\,(\text{equiv wt of metal})}{\text{value of the Faraday}}$$

In the case of nickel, under standard conditions,

Weight of nickel deposited =

$$\frac{2 \times 1.6\text{ cm} \times 0.012\text{ cm} \times 36\text{ amp-sec/cm}^2 \times 29.36\text{ g/equiv}}{96{,}500\text{ coul/equiv}}$$

$= 0.00042$ g
$= 0.42$ mg.

Solution of the Laplace Equation Using Relaxation Methods. The second approach to the solution of the Laplace equation involved the use of relaxation methods,[15, 16] a numerical calculation which does not necessitate any special assumptions and in which cylindrical symmetry can be taken into account. The procedure involved breaking up the field whose potential is desired into a suitable square array of points in a net or mesh, assuming reasonable values of potential at each point in the net, and then applying the difference form of Laplace's equation successively to each of the points. With repeated applications of the procedure, values of potential at any point in the net should converge rapidly to the correct value.[17] After spending several weeks with a desk calculator, an automatic computer was utilized in speeding the computation.

With mesh size of 0.001 cm in the final net and calculations carried to a depth of 0.034 cm from the mouth of the crevice, Wagner's conclusion, that the current density of the lateral faces of the crevice quickly becomes very small in cases, such as this, where the depth of the crevice greatly exceeds its width, is numerically confirmed.

Values of current density found by this method are shown in Table III expressed in ratio form to the exterior current density. If the current efficiency is assumed to be everywhere constant, this value is equal to the thickness ratio. Assigning a normal thickness of 0.012 cm, based on the standard conditions, to the unslotted portion of the cathode yields thickness values given in the third column.

The thickness values at the various distances from the crevice mouth yield a smooth curve from which the total volume of nickel metal on one internal face of the crevice may be easily found by suitable approximation methods. From this volume and the density of nickel, the weight of metal deposited is found to be 0.32 mg.

Extrapolation of Experimental Data. It is evident from Eq. (58) (to be dealt with more fully in the section on secondary current distribution) and from Wagner's discussion preceding it in his paper, that the greater the ratio of the width a of the crevice to the polarization parameter k_e, the smaller is the divergence between the primary and the secondary current distribution. This effect has been experimentally observed in the greater non-uniformity of deposit thickness when the value of k_e was made small by a decreased bath conductivity or a high applied current density.

Consequently, the amount of metal deposited in the crevice under negligible polarization may be estimated by extrapolation of experimental results to very low values of k_e, such as might result from a current density near the limiting value or a vanishingly small concentration of metal ion in the bath. Unfortunately, direct determinations cannot be made under these conditions because of the drastic reduction in current efficiency. However, it is possible, by extrapolation of the values found in the region of approximately 100 per cent efficiency, to estimate the value which would have been obtained could the actual measurements have been made.

Application of this method to actual data yields the following based on an average value for two or more baths: (1) extrapolation to 20 amp/dm² gives 0.2 mg and (2) extrapolation to zero nickel ion content in the bath gives 0.6 mg. (Data collected from baths containing a supporting electrolyte were excluded from this extrapolation.)

Direct Experimental Determination. Several methods by which current and potential distribution in the absence of polarization may be determined experimentally have been described in the literature.[18, 19, 20] The model suggested by Kinney and Festa,[20] in which the cross-sectional geometry of the electroplating cell is reproduced on conducting paper, would be especially applicable to the present case. Unfortunately, a lack of time prevented the assembling of this apparatus and the recording of measurements.

Comparison of Estimated Values for Primary Current Distribution. It is seen from Eq. (14) of Wagner's paper, from which Eq. (22) was derived, that the current density at the mouth of the crevice ($y' = 0$) has an infinite value. In contrast to this, numerical approximations necessarily yield a finite value at $y' = 0$ (cf. Table III), although the value obtained approaches infinity as the size of the net approaches zero. The current I for one face of the crevice as listed in Table III is found to be about 25 per cent less than the value deduced from the analytical solution in Eq. (22). It is to be expected that this discrepancy would decrease as the relaxation was carried to greater refinement. Unfortunately, in the present case the amount of time which would be required for this was prohibitive.

An alternate explanation of the discrepancy between the two solutions of the Laplace equation is that the assumption of rectangular symmetry inherent in Wagner's analysis is not sufficiently realistic when applied to the present geometry. In the absence of a direct experimental determination, it appears that the total metal plated on one internal surface of the 0.012 × 0.8 cm crevice is in the range of 0.35–0.45 mg. The various estimates from all the approaches used are summarized in Table IV.

SECONDARY CURRENT DISTRIBUTION

The secondary, or actual, current distribution inside the experimental crevice would be expected to be significantly

TABLE I

COMPOSITION OF VARIOUS ELECTROLYTIC PLATING BATHS

Bath	Nickel Sulfate $NiSO_4 \cdot 6H_2O$ (g/L)	Nickel Chloride $NiCl_2 \cdot 6H_2O$ (g/L)	Nickel Carbonate $NiCO_3$ (g/L)	Sulfamic Acid NH_2SO_3H (g/L)	Potassium Chloride KCl (g/L)	Boric Acid H_3BO_3 (g/L)	Proprietary Wetting Agent (ml/L)	Hydrochloric Acid HCl	Sulfuric Acid H_2SO_4 (g/L)	Copper Sulfate $CuSO_4 \cdot 5H_2O$ (g/L)	Sodium Lauryl Sulfate $NaC_{12}H_{25}SO_4$ (g/L)
A	240	45	to adjust *p*H			30	5		to adjust *p*H		
B	120	22	to adjust *p*H			30	5		to adjust *p*H		
C	90	17	to adjust *p*H			30	5		to adjust *p*H		
D	60	11	to adjust *p*H			30	5		to adjust *p*H		
E		300	to adjust *p*H			30	5	to adjust *p*H			
F		240	to adjust *p*H			30	5	to adjust *p*H			
G		180	to adjust *p*H			30	5	to adjust *p*H			
H		120	to adjust *p*H			30	5	to adjust *p*H			
I		60	to adjust *p*H			30	5	to adjust *p*H			
J		240	to adjust *p*H		18	30	5	to adjust *p*H			
K		180	to adjust *p*H		36	30	5	to adjust *p*H			
L		120	to adjust *p*H		54	30		to adjust *p*H			
M		60	to adjust *p*H		72	30		to adjust *p*H			
N	315		to adjust *p*H			30	5		to adjust *p*H		
O	135		to adjust *p*H			30	5		to adjust *p*H		
P			227	372		30	0.3				
Q			182	300		30	0.3				
R			170	273		22	0.2				
S			113	186		30	2.6				
T									50	275	1.0
U									50	138	1.3

TABLE II

CONDITIONS AND DATA ON EXPERIMENTAL RUNS

Code No.	Bath	Metal-ion Concentration (g/L)	Purification (*)	pH (**)	Temperature (°C)	Current Density (amp/dm²)	Time (min)	Crevice Width a after deposition (cm)	Specific Conductivity (mho/cm)	Tafel Slope b (volt)	k_c (cm) (***)	Measured value of t_{edge} (cm × 10^4)
1	A	60	No	3.7–4.2	60	10.0	6	0.0118	0.090	0.0765	0.0298	7.3
2	A	60	No	4	60	7.5	8	0.0115	0.090	0.0765	0.0398	9.1
3	A	60	No	4	60	4.0	15	0.0116	0.090	0.0765	0.0745	9.1
4	A	60	No	3.6–4.3	60	1.0	60	0.0110	0.090	0.0765	0.298	8.2
5	A	60	Yes	4	60	10.0	6	0.0118	0.099	0.053	0.0228	6.2
6	A	60	Yes	4–4.5	60	1.0	60	0.0106	0.099	0.053	0.228	7.3
7	B	30	No	4	60	7.5	8	0.0126	0.059	0.0765	0.0260	6.6
8	B	30	Yes	4.3–5.2	60	7.5	8	0.0122	0.060	0.053	0.0188	6.4
9	C	22	No	4	60	7.5	8	0.0122	0.049	0.0765	0.0215	6.9

10	D	15	No	4	60	7.5	8	0.0116	0.039	0.0765	0.0173	8.4
11	E	75	No	3.8–4.1	60	7.5	8	0.0114	0.201	0.072	0.0835	8.2
12	F	60	No	4	60	10.0	6	0.0110	0.172	0.072	0.0536	6.9
13	F	60	No	4	60	7.5	8	0.0110	0.172	0.072	0.0715	8.1
14	F	60	No	4	60	4.0	15	0.0122	0.172	0.072	0.134	8.5
15	F	60	No	4	60	1.0	60	0.0102	0.172	0.072	0.536	7.8
16	F	60	Yes	4.0–4.1	60	7.5	8	0.0106	0.196	0.072	0.0815	6.7
17	F	60	Yes	4.0–4.3	60	1.0	60	0.0121	0.196	0.072	0.611	8.0
18	G	45	No	3.9–4.1	60	7.5	8	0.0112	0.141	0.072	0.0585	7.9
19	G	45	Yes	4.0–4.3	60	7.5	8	0.0101	0.154	0.072	0.0640	6.5
20	G	45	Yes	4.0–4.5	60	1.0	60	0.0106	0.154	0.072	0.480	10.4
21	H	30	No	4.1–4.7	60	7.5	8	0.0108	0.110	0.072	0.0459	8.4
22	H	30	Yes	3.8–4.2	60	7.5	8	0.0102	0.124	0.072	0.0515	6.5
23	H	30	Yes	4.0–4.4	60	1.0	60	0.0126	0.124	0.072	0.370	8.6
24	I	15	Yes	3.7–4.1	60	7.5	8	0.0116	0.068	0.072	0.0270	6.5
25	I	15	Yes	4.0–4.7	60	1.0	60	0.0126	0.068	0.072	0.203	8.5
26	J	60	Yes	4.0–4.3	60	7.5	8	0.0108	0.208	0.072	0.0865	7.5
27	J	60	Yes	4.0–4.3	60	1.0	60	0.0119	0.208	0.072	0.649	9.5
28	K	45	Yes	3.6–4.3	60	7.5	8	0.0115	0.198	0.072	0.0815	6.4
29	K	45	Yes	3.8–4.3	60	1.0	60	0.0114	0.198	0.072	0.612	9.4
30	L	30	Yes	4.0–4.5	60	7.5	8	0.0102	0.211	0.072	0.0875	8.4
31	L	30	Yes	4.0–4.6	60	1.0	60	0.0108	0.211	0.072	0.675	8.4
32	M	15	Yes	4.0–4.7	60	7.5	8	0.012	0.208	0.072	0.0865	9.1
33	M	15	Yes	3.7–4.7	60	1.0	60	0.0114	0.208	0.072	0.649	9.3
34	N	70	No	4.0–2.4	60	7.5	8	0.0125	0.073	0.090	0.038	9.2
35	O	30	No	3.8–2.3	60	7.5	8	0.0120	0.054	0.090	0.028	6.5
36	P	112	No	4–2	60	7.5	8	0.0114	0.117	0.10	0.0675	8.2
37	Q	90	No	4–2	60	7.5	8	0.0125	0.115	0.10	0.0675	5.8
38	R	84	No	4–2	60	7.5	8	0.0132	0.112	0.10	0.0645	8.5
39	S	56	No	4–2	60	7.5	8	0.0120	0.107	0.10	0.0615	8.8
40	T	60	No		60	7.5	8	0.0128	0.220	0.07	0.089	6.8
41	T	60	No		25	7.5	8	0.0132	0.180	0.07	0.070	3.5
42	U	30	No		60	7.5	8	0.0126	0.220	0.07	0.089	7.7

*All nickel baths were digested 3 hrs. with a slurry of nickel carbonate and filtered. "Purified" baths were, in addition to this, treated with hydrogen peroxide and activated carbon and "dummied" before use.
**A range here indicates the pH of the bath before and after deposition, respectively.
***k_c, Wagner's "polarization parameter" is calculated from Wagner's Eq. (46), with the terms $RT/\alpha_c zF$ being replaced by the Tafel slope b/ln 10.

different from the primary current distribution because of polarization results in a more uniform distribution of current. The shape of the potential-current density curve must be taken into account in order to predict and understand the actual distribution of electrodeposits on irregularly shaped cathodes.

Theoretical and Experimental Variation of Deposit Thickness with Distance from the Mouth of the Crevice. In his derivations, Wagner[12] proposed two equations to describe the deposit distribution when polarization is taken into account.

$$J(y') = J_{edge} \exp \frac{-y'}{(ak_c/2)^{1/2}} \qquad (38)$$

was derived for a linear polarization curve; while

$$J(y') = \frac{J_{edge}}{\left[1 + \frac{y'}{ak_c(edge)^{1/2}}\right]^2} \qquad (48)$$

was derived for the case where the polarization curve is best described by a logarithmic equation of the Tafel type. In each case:

y' = distance from mouth of crevice
$J(y')$ = current density at given y'
J_{edge} = current density at the mouth of the crevice = $J(y' = 0)$
a = width of crevice
k_c = "polarization parameter," defined as the specific conductivity multiplied by the slope of the polarization curve, on outer surface of cathode; has units of length.
$k_c(edge)$ = polarization parameter corresponding to the current density J_{edge}.

These equations contain the term J(edge). Once this value is known, the deposit distribution within the crevice can be predicted in terms of the bath conductivity, the polarization curve, and the width of the crevice. Such a prediction of the deposit distribution curve, even though it often agrees with experimental data reasonably well, leaves much to be desired in that J(edge) is itself an experimentally determined value. It is far more satisfying if this prediction can be made in terms of a known parameter, such as J_0 in these experiments. For this reason, the actual measured value of J(edge) was avoided in making the tests described below.

The great majority of the experiments were performed with nickel baths, for which activation polarization prevails and which, therefore, yield a logarithmic polarization curve. Equation (48) was thus chosen for extensive testing. The modified form rewritten by Wagner as equation (61) was used in making the actual calculations.

$$\frac{J(y')}{J_0} = \frac{J(edge)/J_0}{\left\{1 + \left[\frac{y'}{(ak_c^0)^{1/2}}\right]\left[\frac{J(edge)}{J_0}\right]^{1/2}\right\}^2} \qquad (61)$$

k_c^0 being the value of the polarization parameter at the current density J_0. This is exactly equivalent to equation (48) since $k_c(edge) = k_c^0\left[\frac{J_0}{J(edge)}\right]$ (59). Values of $J(edge)/J_0$

TABLE III

Distance from crevice mouth (cm)	$\frac{J}{J_0}$	Equivalent Thickness (cm × 10^4)
0.000	1.0204	12.2448
0.001	0.6514	7.8168
0.002	0.4521	5.5452
0.003	0.3285	3.9420
0.004	0.2448	2.9376
0.005	0.1849	2.2188
0.006	0.1407	1.6884
0.007	0.1076	1.2912
0.008	0.0825	0.9900
0.009	0.0631	0.7572
0.010	0.0483	0.5796
0.011	0.0370	0.4440
0.012	0.0283	0.3396
0.013	0.0217	0.2604
0.014	0.0166	0.1992
0.015	0.0128	0.1536
0.016	0.0098	0.1176
0.017	0.0076	0.0912
0.018	0.0059	0.0708
0.019	0.0047	0.0564
0.020	0.0037	0.0444
0.021	0.0031	0.0372
0.022	0.0025	0.0300
0.023	0.0021	0.0252
0.024	0.0018	0.0216
0.025	0.0015	0.0180
0.026	0.0012	0.0144
0.027	0.0009	0.0108
0.028	0.0007	0.0084
0.029	0.0004	0.0048
0.030	0.0003	0.0036
0.031	0.0003	0.0036
0.032	0.0002	0.0024
0.033	0.0001	0.0012
0.034	0.0000	0.0000

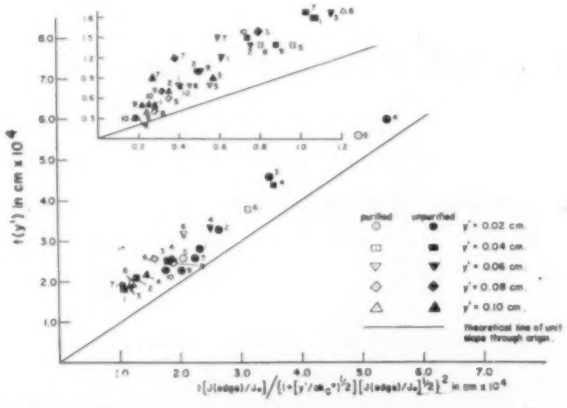

Fig. 2. Experimental values of deposit thickness at various distances from crevice mouth vs. values predicted by Eq. (61). Watts-type nickel baths.

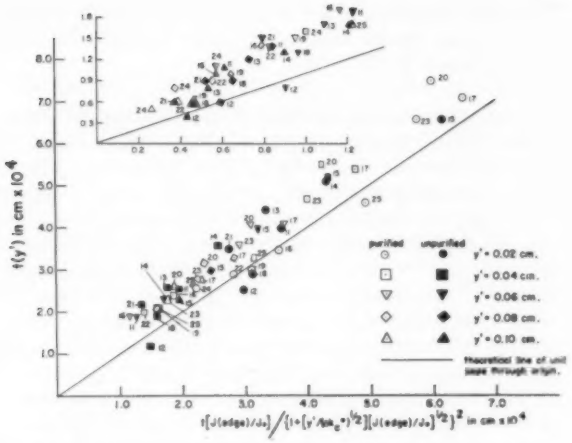

Fig. 3. Experimental values of deposit thickness at various distances from crevice mouth vs. values predicted by Eq. (61). All-chloride nickel baths.

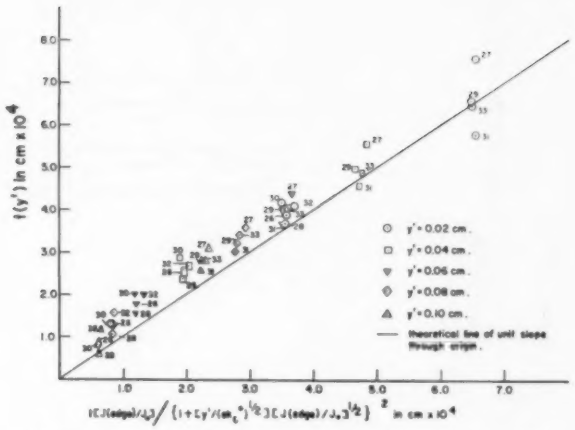

Fig. 4. Experimental values of deposit thickness at various distances from crevice mouth vs. values predicted by Eq. (61). All-chloride nickel baths containing KCl.

were found from Wagner's Fig. 5, curve b, which relates a predicted value of the ratio $J(edge)/J_0$ to k_c^0/a.

Measured thickness values, rather than current density J values were employed in all the tests. It was assumed that the current efficiency was 100 per cent over the entire cathode and thus $\frac{t(y')}{t_0} = \frac{J(y')}{J_0}$ where t represents the deposit thickness.

The experimental data obtained in the Watts bath, the all-chloride nickel bath, the all-chloride baths containing KCl and varying metal concentrations, and the all-sulfate and all-sulfamate nickel baths and acid copper baths are summarized in Figs. 2–5. In each figure the theoretical curve of unit slope as predicted by Wagner's equation (61) is given for reference. The number beside each point is the code number as given in Table II. In all four plots the great majority of the points lie on a line above and parallel to the theoretical line. Equation (61) has approximately the same validity at all the depths in the crevice which were tested, except in the case of the all-sulfate nickel and acid copper baths at the greater depths, where the deposit thickness was appreciably less than the theoretical prediction. Low current efficiency at the low current densities within the crevice is probably a factor in these cases.

An alternative way of presenting the comparison between the theoretical prediction and experimental data is given in Figs. 6–8 in which the experimental points at various depths are compared with the theoretical curve. In the case of the all-chloride bath at the three current densities shown, the deposit thickness at all depths was greater than that predicted by Wagner's equation (61).

At a value of $t_0[J(edge)/J_0]/\{1 + [y'/(ak_c^0)^{1/2}][J(edge)/J^0]^{1/2}\}^2 = 3.0$, the discrepancy between the experimental and theoretical curves in Fig. 3 was 0.00006 cm, in Fig. 4 it was 0.00005 cm, and in Fig. 5 it was 0.00004 cm. It is not possible at the present time to account satisfactorily for the discrepancy. The most likely explanation is that there was an approximately constant error in the measurement of the thickness of the deposit. Other possible explanations include the following: (1) The deposit may not have been uniformly compact so that the thickness does not bear a direct relationship to the current density. (2) Spurious local galvanic effects may have been present in the crevice. (3) Concentration polarization effects may have been different on the exterior of the cylinder, at the mouth of the crevice, and within

TABLE IV

ESTIMATES OF THE TOTAL AMOUNT OF NICKEL ON ONE INTERNAL SURFACE OF THE 0.012 × 0.8 cm CREVICE ASSUMING PRIMARY CURRENT DISTRIBUTION

Method	Amount of Nickel
Approximation based on area of opening	0.66 mg
Solution of the Laplace equation using conformal mapping	0.42
Solution of the Laplace equation using relaxation methods	0.32
Extrapolation of experimental results to high current density	0.2
Extrapolation of experimental results to zero metal content	0.6

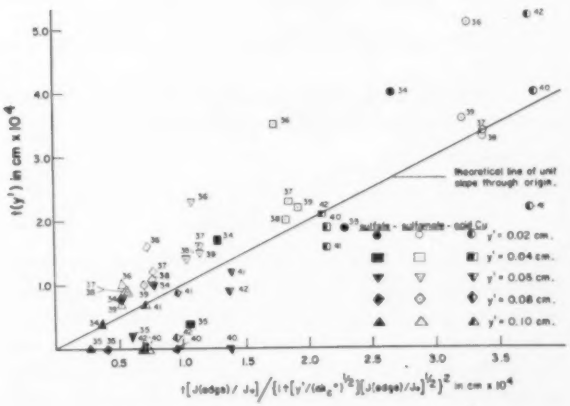

Fig. 5. Experimental values of deposit thickness at various distances from crevice mouth vs. values predicted by Eq. (61). All-sulfate and all-sulfamate nickel baths and acid copper baths.

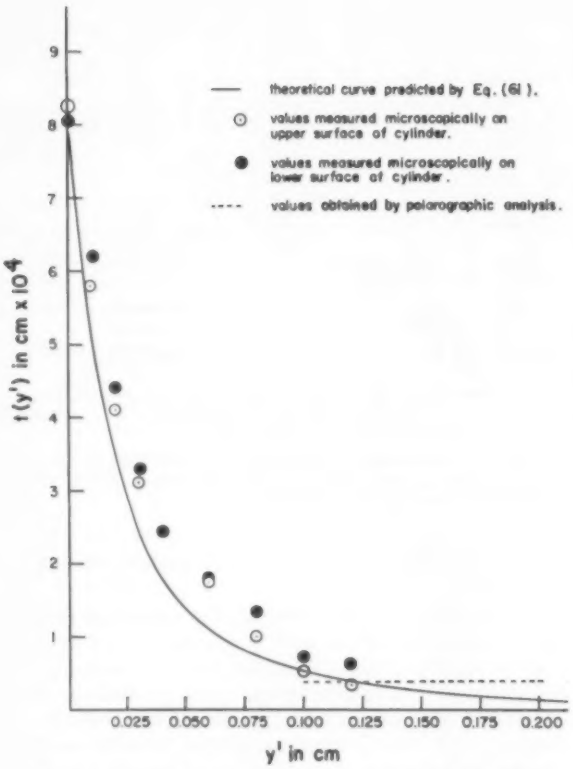

Fig. 6. Measured and theoretical values of deposit thickness vs. distance from crevice mouth for all-chloride bath at 7.5 amp/dm². (Code No. 13.)

the crevice. (4) The approximations used in the derivation of the equations may significantly affect their validity. (5) The polarization curves, and thus the Tafel slope b, of the baths used may have been different from the curves taken from the literature. In view of all the uncertainties, the approximate agreement between observed and calculated values seems remarkable and of much greater importance than the divergence.

Predicted and Experimental Values of Total Metal Deposited in Crevice. Utilizing equation (48), Wagner derived equation (58), namely,

$$J(\text{slot}) = 2[k_c(\text{edge})/a]^{1/2} J(\text{edge}),$$

where J(slot) represents the density of current lines entering the slot.

The total weight of metal deposited in the crevice is determined by the current entering the slot as follows,

wt of metal =

$$\frac{(J(\text{slot}))\ (\text{"entrance area"})\ (\text{time})\ (\text{equiv wt of metal})}{\text{value of the Faraday}}$$

The term "entrance area" refers to the width of the crevice multiplied by the circumference of the cylinder. In calculating J(slot), equation (59) was employed to find $k_c(\text{edge})$.

A plot is given in Fig. 9 of the experimental values in relation to the values calculated from equation (58). The experimental value was calculated from the microscopic measurements of the thickness at various depths. Since equation (58) was derived on the assumption of a rectangular slot, the calculations were also made on that basis, the "breadth" being taken as the circumference of the cylinder. The number beside each point again is the code number as given in Table II.

Comparison of Experimental and Theoretical Values of the Ratio, J(edge)/J₀. In his Fig. 5 Wagner gives in graphical form the relationship between J(edge)/J₀ and k_c^0/a. The experimental test of this relationship given in Fig. 10 shows that this relationship is not accurately obeyed in these experiments. It appears that the actual value of J(edge) is extraordinarily sensitive to the experimental conditions existing at the mouth of the crevice. It is our view that this sensitivity is caused by factors affecting streaming of the cathode film in the immediate vicinity of the crevice mouth. These factors include the perfection of the edge prior to plating, the degree and constancy of stirring during the experiment, and the accuracy with which the cylindrical surface of the electrode was aligned with the vertical. Cathode film studies of the type made by Beacom[21] were carried out and it was noted that the streaming of the cathode film around the crevice opening could take many forms depending upon the exact conditions of the experiment.

DISCUSSION

When the program for this study was first under consideration, it was recognized that there were few satisfactory experimental data at hand for the deposit distribution on small-scale recesses. It appeared very difficult to use the available data for quantitative testing of any theory of deposit distribution. It was thus apparent that the first objective of Project

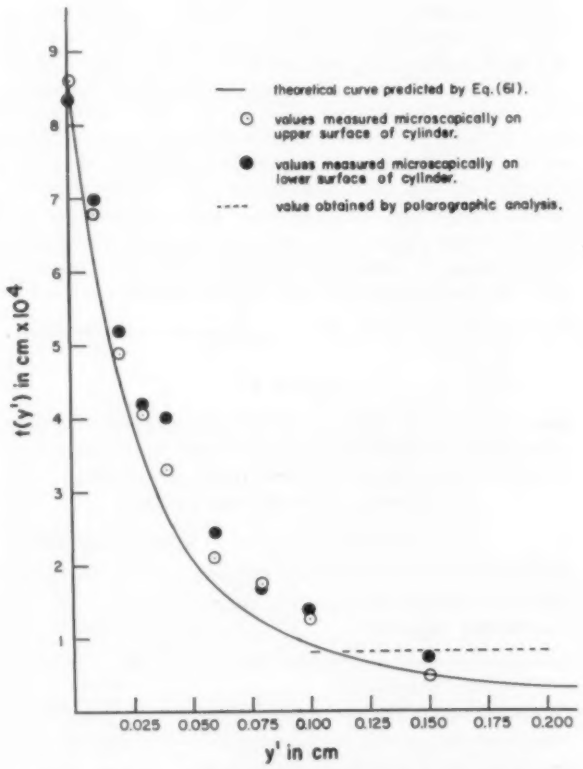

Fig. 7. Measured and theoretical values of deposit thickness vs. distance from crevice mouth for all-chloride bath at 4.0 amp/dm². (Code No. 14.)

No. 17 was to obtain experimental data which were susceptible to quantitative analysis.

The Cathode. Although the geometry of the crevice used in the study bears little relationship to any normally encountered in the practical electroplater's shop, it is useful because it serves as a controllable model for quantitative testing of theory. The cathode used in the study was chosen primarily because the width and depth of the crevice could be controlled; uniform current density distribution on the majority of the plated area external to the crevice could be readily obtained; the internal surface of the crevice could be cleaned; the surface structure and type of basis metal could be altered at will; and the crevice could be formed without the danger of entrapped air. The cathode has proven itself of great value from an experimental point of view but it possesses the important disadvantage from a theoretical point of view that a representative segment of the crevice is a sector of a circle. This geometrical consideration becomes of great importance when the value of k_c is large enough so that a significant amount of deposit is formed deep within the crevice but is of no great importance for values of k_c in the range used commercially. This disadvantage is far outweighed by the ease in handling the cathode.

Comments on Wagner's Analysis. It is apparent from the rather good agreement between Wagner's predictions and the experimental results shown in Figs. 2–9 that the deposit distribution obtained with the nickel and acid copper baths can be explained on the basis of polarization theory. No new

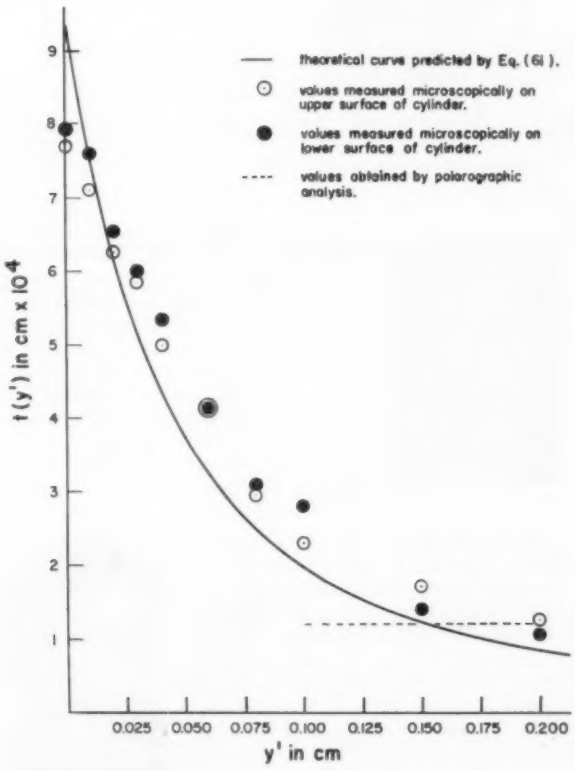

Fig. 8. Measured and theoretical values of deposit thickness vs. distance from crevice mouth for all-chloride bath at 1.0 amp/dm². (Code No. 15.)

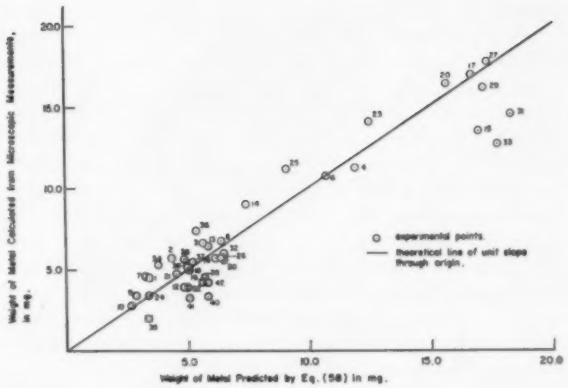

Fig. 9. Experimental values of total weight of metal deposited in crevice vs. values predicted by Eq. (58).

phenomena need to be invoked in order to understand the deposit distribution in a deep and narrow crevice such as used in this study.

Consideration should be given to the limitations with which Wagner's equations may be applied to actual profiles which might be encountered in research or in practical plating. First of all, the results of this study should not be taken to contradict the observations and conclusions of other workers who used very shallow crevices such as might be obtained by scratching the surface or indenting it with a sharp instrument. Although Wagner's equations (29), (30), and (31) apply to any crevice, equations (38), (48) and (61) were derived after the introduction of certain assumptions which restrict the use of the latter equations: (1) The depth of the crevice was assumed to be much greater than the width. (2) The width of the crevice was assumed to be much less than the polarization parameter k_c. (3) It was assumed that the same polarization curve applied over the entire cathode profile. Modification of any of these conditions would change the final form of equations (38), (48), and (61).

Cyanide Copper Baths. The poor throwing power of cyanide copper baths in small cracks and holes has been observed by Reinhard,[5] by Raub,[6] and by Foulke and Kardos.[8] However, some investigators have reported good microthrowing power from cyanide copper baths. Dettner[22] found

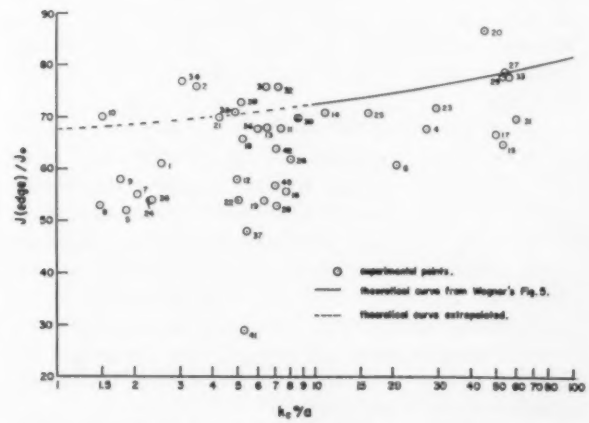

Fig. 10. Experimental test of the relationship between J(edge)/J_0 and k_c'/a predicted by Wagner.

good microthrow for a high conductivity bath operated at low current densities. Killer[22] found the deposit distribution to vary with the current efficiency within the same crevice as used in this study. At low efficiencies the gas formed in the crevice could not escape readily and it thus served as an insulator preventing further deposition. Unfortunately sufficient time was not available to determine whether the microthrowing power of cyanide copper baths could be explained quantitatively on the basis of the conductivity of the bath, the slope of the polarization curve, and the current efficiency. A possible source of the different results obtained by different investigators may lie in the different formulations and the different plating conditions used. Current efficiency effects would only be expected to play an important role in deep and narrow crevices.

Leveling. In Wagner's Fig. 5 it will be noted that the ratio of J(edge)/J_0 is a function of k_c^0/a. From the shape of the curve it can be seen that J(edge) does not exceed J_0 for any normally-encountered values of a and k_c. Also, it is seen from Eq. (61) that no J(y′) exceeds J(edge) and thus must be less than J_0 also. However, it is known from practical experience with leveling baths and from the results of this study (see, for example, Fig. 13 in reference (11)) that J(y′) can exceed J_0 by a large amount. This apparent inconsistency is explained by the fact that inherent in Wagner's derivation is the assumption that the same polarization curve applies at all points during plating. In the case of leveling baths containing added agents the polarization curve varies from site to site as a consequence, in part, of the varying concentration of the addition agent at various sites on the surface. It is well known that the polarization curve at a given current density is, within limits, a function of the concentration of the added agents in the plating baths. This concentration varies from peak to recess over a cathode profile as predicted by diffusional theories of leveling.[8, 9, 10] Since the baths used in gathering the results reported in this paper contained no leveling agents, Wagner's assumption of the same polarization curve over the entire cathode is valid in the present case.

Suggestions on Improving Microthrowing Power. The results of this study yield some generalizations which may be useful to the practical plater in controlling his operations so as to improve microthrowing power when required.* Since the plater usually has little control over the microgeometry of the cathode, good microthrowing power must depend on bath formulations and operating conditions. These should be chosen in such a way as to maximize the value of the polarization parameter, k_c, which is the most important variable in determining the current distribution on a given microprofile.

k_c is the product of the conductivity and the slope of the polarization curve, and thus experimental conditions which affect either of these parameters will affect the microthrowing power. The value of k_c may be increased by any factor which increases the conductivity, such as an increase in temperature or the addition of a supporting electrolyte to the bath. The slope of the polarization curve may be increased by lowering the current density or by the choice of a plating bath with a steep polarization curve. In general, then, the greater the value of these two factors, the more uniform the deposit distribution over a microprofile.

*Although the crevice used in this study might not be considered a "true" microrecess, it is nevertheless felt that these suggestions are of general applicability.

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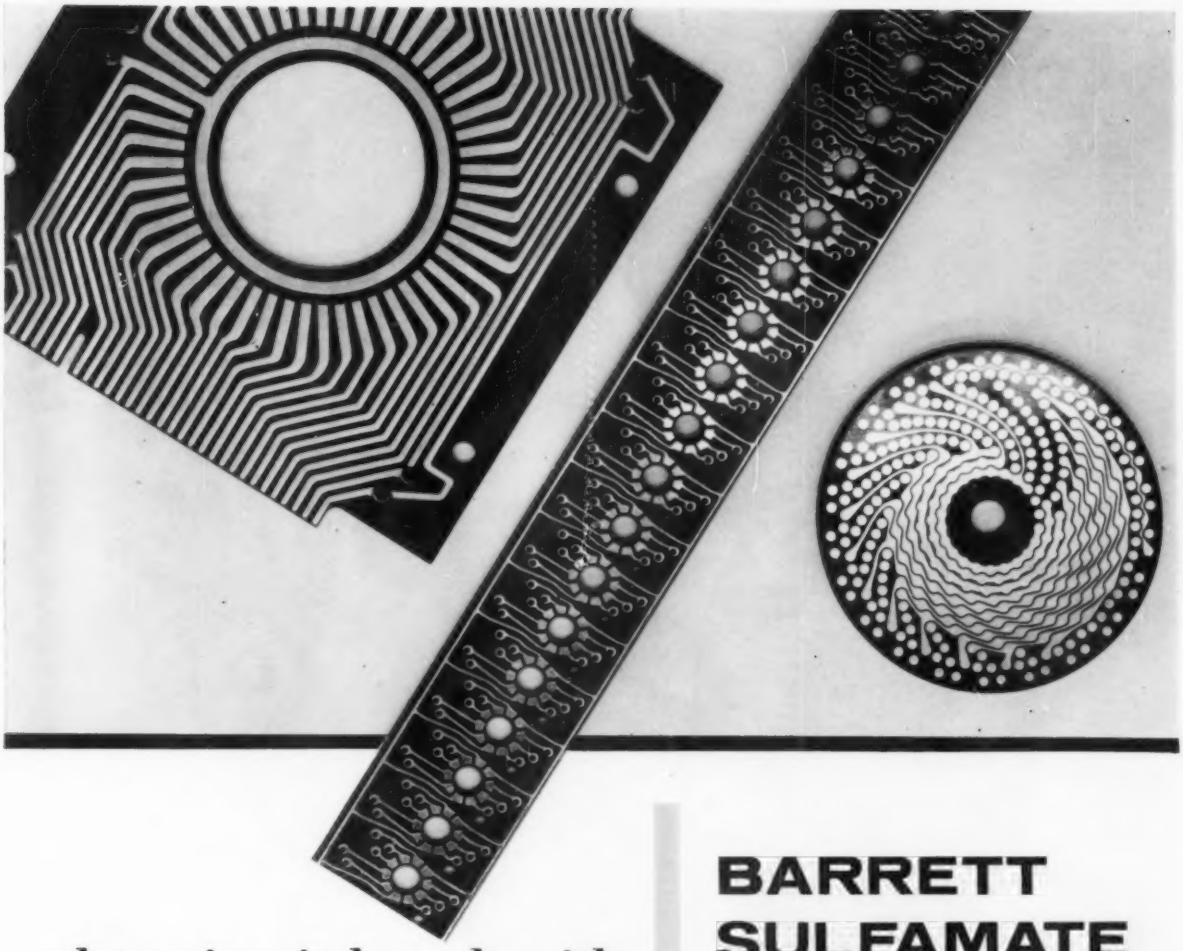
Henry Leidheiser Jr. obtained his BS degree in 1941 and his PhD degree in 1946 from the University of Virginia. He remained at the University as a research associate until June 1949, at which time the laboratory of the Virginia Institute for Scientific Research began operations. He is currently Director of the Institute. Dr. Leidheiser is active in the Virginia Academy of Science, in the Virginia Section of the American Chemical Society, and as an abstractor for Chemical Abstracts.

Lucille B. Garmon received a BS with major in chemistry in 1957 from the University of Richmond, and an MS from the same institution in 1960. Since 1957 she has been employed as a research chemist at the Virginia Institute for Scientific Research, where she has done work mainly in the fields of electrochemistry and crystallography.

Mrs. Garmon is a member of the American Chemical Society as well as various honorary organizations, including Phi Beta Kappa.



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- Exceptionally low tensile stress without the use of organic addition agents
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2 OPERATIONS SAVED.
On base of small waffle iron, 1 cut-down operation, and 1 hand coloring operation have been eliminated through the use of Superlume.

1 OPERATION SAVED.
On base of large waffle iron, 1 coloring operation is no longer necessary.

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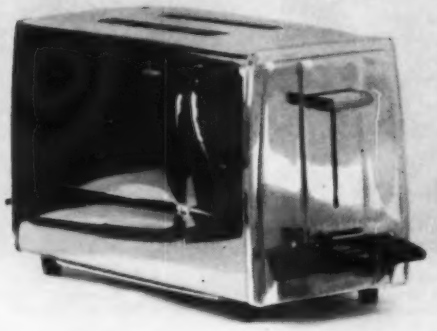
On round toaster shell, 1 cut-down operation and 2 coloring operations have been eliminated.

1 OPERATION SAVED.
On the steam iron shoe, 1 hand coloring operation has been eliminated.

yet SUPERLUME vastly improves all 5 of these Son Chief products ...and at no extra cost.

says NICHOLAS J. LAZZARO, JR.
Asst. Plant Superintendent
in Charge of Finishing,
Son Chief Electrics, Inc.,
Winstead, Connecticut



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On square toaster shell, same finishing operations are required with Superlume, but appearance of product is tremendously improved. On all 5 products, in fact, Superlume has stepped up product quality appreciably—and, in every instance, *at no increase in cost.*

Son Chief Electrics, Inc., appliance makers, sought a thicker, brighter plate, more rapidly applied. They found it in Superlume—along with major reductions in finishing operations, plus what Nick Lazzaro calls "Tremendous improvement in our products' appearance . . . a real breakthrough in quality."

Actually, Son Chief is plating *twice* as thick in the same time as before (using 60 amps per sq. ft. instead of 30).

They're plating flat pieces now and forming *after* plating . . . a big production advantage unique with highly ductile Superlume.

Superlume bath is easier to maintain. Son Chief's normal operating schedule is 5 days, 16 hours a day. But for two months every year, they work on a *24-hour/5-day basis.* Average pieces per hour through trouble-free Superlume: 336, with a low of 226, a high of 904. Son Chief plates 30 different parts ranging from 1 to 20 inches long. Superlume bath in use: 3100 gallons.

Good-sized operation . . . healthy benefits . . . no added production costs. For full facts on Superlume as applied to *your* operation, contact H-VW-M. Chances are you, too, will be better off with this better bright nickel bath.

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Constitutional & Bylaw
Revision Committee

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Ralph H. McCahan
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Herberth E. Head
Chairman
Honorary Membership Committee

LEADERSHIP

BOARDS AND COMMITTEES

AMERICAN ELECTROPLATERS' SOCIETY

1961-1962

Manson Glover
Chairman
Law Committee

Irvin M. Weiss
Chairman
Membership Committee

Dr. Martin S. Frant
Chairman
Paper Awards Committee

Francis T. Eddy
Chairman
Publications Committee

Allen Ferguson
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Chester G. Borlet
Chairman
Proctor Award Committee

Dr. Harold J. Wiesner
Chairman
Research Committee

Dr. A. Kenneth Graham
Chairman
Scientific Achievement Award
Committee

Herman A. Tessmann
General Chairman
1962 AES National Convention

AES NEWS

Edward C. Bertucio

BERTUCIO NAMED EDITOR OF AES's 1961-1962 SPEAKERS LIST

To succeed Rafael Diaz whose term has expired as a member of the AES Educational Committee, Edward C. Bertucio, current Secretary of that Committee, has been named Editor of the AES's 1961–1962 Speakers List and will have the responsibility of creating that 1961–1962 Edition. He is associated with the International Nickel Company.

Every speaker whose availability, speech title and speech abstract were included in the 1960–1961 Speakers List disseminated in May 1961, will soon be given opportunity by Mr. Bertucio to confirm his continued availability and to review his abstract within a firm deadline date to be specified in Mr. Bertucio's communication. Expectedly, the 1961–1962 Speakers List will be completed and disseminated among Branch Educational Chairmen early next Spring.

COMMITTEE ACTIVATED TO PREPARE NEW AES CONSTITUTION AND BYLAWS FOR SUPREME SOCIETY ACTION

Every progressive enterprise and establishment, including progressive Societies and Associations, must, as they accumulate age-years and longevity against the background of changing times, keep their governmental structure and policies modern and effective so as to achieve continued durability and continued progress. In this spirit and to this end, the Supreme Society, summit governing council of 52-year old American Electroplaters' Society, Inc. (AES), took a significant step at its Annual Meeting held in Boston, Massachusetts, June 22, 1961.

Convinced that a reconstruction of the AES's current Constitution and Bylaws is vital to the Society's progress, the Supreme Society, at its Boston Annual Meeting, instructed the Executive Board to activate a competent AES Constitution and Bylaw Revision Committee, and charge it with the task of completing such an instrument at the earliest possible time, and of properly processing it for consideration and possible adoption at the Milwaukee Annual Meeting, June 28, 1962.

At its June 23 meeting, the Executive Board immediately answered the Supreme Society's directive by appointing and activating a nine-man AES Constitutional and Bylaw Revision Committee. To head that significant body, it named Past National President Cleveland F. Nixon (Detroit Branch) as Chairman. As Mr. Nixon's second-in-command, it named Leslie L. Diveley (Milwaukee Branch) as Vice Chairman. It appointed Manson Glover (Boston Branch) as Secretary.

As members of that Committee, the Board also appointed Past National Presidents Clyde Kelly (Chicago Branch), Francis T. Eddy (Los Angeles Branch) and William J. Neill (Columbus Branch), plus Branch Secretary I. William Marcovitch (Philadelphia Branch), Past Branch President Kergan Wells (Toronto Branch) and Past Branch President Myron E. Browning (Dallas-Fort Worth Branch). It also appointed National Executive Secretary John P. Nichols as Consultant to the Committee, and also appointed each member of the Executive Board itself as ex-officio a Committee member.

Under the leadership of Committee Chairman Nixon, the Committee immediately started work. Its timetable targets completion of a first draft by September 1961—development of that draft to a second draft for preliminary consideration at the Ninth Interim Meeting of the Supreme Society, January 13, 1962—completion of the final draft thereafter as quickly as possible.

To that same Committee for action, the Supreme Society also referred the Board's proposed increase of the Per Capita Tax of Active Members and the dues of Members-at-Large (see May 1961 issue of PLATING MAGAZINE), effective during the fiscal year July 1, 1962–June 30, 1963.

CENTRAL IOWA BRANCH PERMANENTLY CHARTERED BY THE EXECUTIVE BOARD

Having successfully operated over three months from April 1, 1961 as a temporarily chartered Branch of American Electroplaters' Society, Inc. (AES), the Central Iowa Branch, twenty-six member strong and increasing, was permanently chartered as an AES Branch by the Executive Board recently, effective August 1, 1961.

The neophyte Branch will be installed as AES's 61st permanently chartered Branch at an installation meeting soon to be scheduled. There, an installation team of National Officers will orient the Branch, present its charter and install its first slate of elected permanent officers.

AES's Branch expansion record is impressive. Since 1956, Branches have been added in 1) British Columbia, 2) Miami, 3) Mohawk Valley, 4) Blue Ridge, 5) Phoenix, 6) Denver, 7) Memphis-Midsouth, 8) San Diego and 9) Central Iowa. In addition, AES currently has its Santa Clara Branch (California) under Temporary Charter, effective July 1, 1961. After its three-month probationary period, Santa Clara will expectedly earn election as AES's 62nd Branch.

Cleveland F. Nixon

NEW YORK BRANCH ANNOUNCES SPEAKERS FOR METROPOLITAN REGIONAL MEETING

Two prominent speakers are scheduled for the Third Annual Metropolitan Regional Technical Session to be held on Friday evening, September 22 in the Hotel Statler-Hilton, New York City.

The Metropolitan Regional is composed of the Newark and New York Branches. The two Branches alternate in conducting the Regional Technical Sessions. This year, New York is the Host Branch.

Walter Schwartz, Enequist Chemical Company, educational chairman, will present John B. Winters of Incar, Inc., who will speak on "The Anode's Side of the Story," and Jack B. Kerr, Reynolds Metals Company, whose paper will be "Finishes for Aluminum."

The meeting will start at eight o'clock in the Skytop Room of the hotel.

NINTH INTERIM MEETING
SUPREME SOCIETY
AMERICAN ELECTROPLATERS' SOCIETY
MAROTT HOTEL
INDIANAPOLIS, INDIANA
SATURDAY, JANUARY 13, 1962
ARRANGEMENTS BY
AES INDIANAPOLIS BRANCH

ATOMIC RESEARCH LABORATORY SITE OF MIDWEST REGIONAL COUNCIL TECHNICAL SEMINAR

by ALEXANDER ALEXANDER

In keeping with the traditional choice of holding its annual technical seminar at institutions of higher learning—which began with the first meeting at Rockford College in 1959, then on to Notre Dame University in 1960—the Midwest Regional Council has chosen a most interesting unit of the University of Chicago, Argonne National Laboratories, Lemont, Illinois, one of the three large atomic research laboratories operated for the Atomic Energy Commission, as the site of its October 28 Third Annual Seminar. This site is in keeping with the scientific nature of a symposium, "Plating on Uncommon Basis Metals", which will highlight the session.

The rapid advancements of science, spurred on by the atomic age and the space era, are making more and more demands upon the electroplating and finishing industry for finishing of metals never before used. These requirements are becoming increasingly common. Papers dealing with plating on chromium, titanium, uranium, tungsten and precious metals, as well as one on the deposition of uranium from molten salts will make this symposium a milestone in the technical advancement of our industry and a major achievement of the Midwest Regional Council.

As has been the practice in the past, a series of workshops on practical finishing operations will also be held in other rooms of the laboratory. The workshops and their respective moderators will be as follows: *Organics*, Tom McCullough, National Lock Co.; *Cleaning*, S. P. Gary, Scientific Control Labs.; *Pickling*, Dr. Russel E. Harr, Western Electric Co.; *Barrel Plating*, E. P. McCoy, Electrochemical Products Co.

Due to limited facilities at Argonne National Laboratories, registration will be limited to available seating capacity. Each Midwest Branch will be advised of its prorated quota which will be on a first come, first served basis. Under no circumstance will there be any registration at the site.

A guided tour of the atomic reactors and general facilities should in itself more than justify a large attendance. A fine steak dinner will be included in the $9.00 registration fee.

Aerial view of Argonne National Laboratories where basic research is performed on atomic energy for peace time applications.

REMINDERS TO AES CHARTERED BRANCHES

The list of your Branch's duly elected Branch Delegates and Alternate Delegates for 1961-1962 is due in the hands of the National Executive Secretary by or before *November 6, 1961* for accreditation. (Reference: AES Bylaws, Part II, Article VII, Section 1). Your list should be filed on the official form that has been provided to you by National Headquarters, and must be signed by both the Branch President and Branch Secretary.

♦

Your Branch, via its accredited Delegates, has been invited to nominate any qualified member of the Society whom it chooses for consideration for the AES Scientific Achievement Award for 1961-1962. Your choice must be supported by *seven* copies of a statement of your nominee's qualifications. These are all due in the hands of the National Executive Secretary by not later than *October 15, 1961* by the Award's regulations. No nominations will be accepted after that date.

♦

Your Branch, via its accredited Delegates, has been invited to nominate any qualified member of the Society whom it chooses for consideration for AES Honorary Membership. Your choice must be supported by six copies of a statement of qualifications. These are all due in the hands of the National Executive Secretary by not later than *November 15, 1961* by the recorded rules of the Supreme Society. No nominations will be accepted after that date.

♦

Your Branch, through its President of record, will be invited to nominate any member of the Society whom it chooses for consideration for the Charles Henry Proctor Memorial Leadership Award for 1951-1962. More information soon.

♦

If your Branch is among those very few Branches that have delayed to now in appointing a Branch Research Finance Chairman to spearhead your Branch's effort to stimulate Sustaining Membership applications by industrial companies in your area, with the help of the Regional Research Finance Chairman for your territory, please do so promptly and submit his name to the National Executive Secretary's office at earliest possible time for processing.

BRANCHES POLLED FOR CANDIDACIES FOR HIGH AES 1961-1962 HONORS

All AES Branches have now received opportunity through official Return Sheets recently sent by National Headquarters, to nominate candidates for 1) the 1961–1962 AES Scientific Achievement Award and 2) AES Honorary Membership. The specifications for each honor not only accompanied the Return Sheets but are also spread in the Appendix of the AES Constitution and Bylaws booklet, possessed by all Branches and their Delegates/Alternates.

Deadline for all Branch nominations for the AES Scientific Achievement Award is by or before October 15, 1961; for AES Honorary Membership by or before November 15, 1961. Each executed Return Sheet filed with the National Executive Secretary by deadline must be signed as specified, and each must be accompanied by the requisite number of copies of profiles of the qualifications of endorsed candidates.

Similar Return Sheets will soon issue to all AES Branches and to all AES Committees for candidates for the 1961–1962 Charles Henry Proctor Memorial Leadership Award.

ANNOUNCEMENT OF PROPOSAL TO AMEND THE SOCIETY'S CONSTITUTION

By a resolution unanimously adopted by the Supreme Society, summit governing council of American Electroplaters' Society, Inc., at its Annual Meeting held in Boston, Massachusetts, June 22, 1961, the Executive Board has been directed to invoke the initiative and referendum provisions of Part III, Article I, Sections 1–3 of the Constitution of the Society and bring the following proposed amendment of said Constitution to a vote of the accredited Delegates composing said Supreme Society by Letter Ballot:

> That Part I, Article VIII, Section 2 of said Constitution be amended so as to delete the mandatory requirement that a copy of the annual AES book, TECHNICAL PROCEEDINGS, be issued to each AES member in good standing as an entitlement of his AES membership.

Each accredited Delegate of the Supreme Society will consequently soon receive a proper Letter Ballot for his vote on this proposal.

All sealed Ballots thereafter received at National Headquarters by a deadline date to be specified on said Ballot, will then be presented for count to an official Committee of Tellers to be appointed by the Executive Board.

In conformity with the recorded policy of the Supreme Society, ". . . returns from at least one-half the Delegates shall be necessary for validity."

Pursuant to Part III, Article I, Section I of AES's Constitution, the proposition will be successful and the Constitution validly amended as proposed, if it receives the favorable Letter Ballot vote of two-thirds of the aggregate number of accredited Delegates voting, so long as that aggregate voting number, as stated, constitutes at least one-half of all of the Society's accredited Delegates.

The pro or con result of this Letter Ballot action will both be announced by mail to AES Branches and published in PLATING MAGAZINE as promptly as possible after having been determined.

PERSONNEL OF AES's CONSTITUTION AND BYLAW COMMITTEE

Top row, left to right, National Past President Clyde Kelly, Chicago Branch; Leslie L. Diveley, Milwaukee Branch; Manson Glover, Boston Branch; National Past President William J. Neill, Columbus Branch; Bottom row, Myron E. Browning, Dallas-Fort Worth Branch; National Past President Francis T. Eddy, Los Angeles Branch; I. William Marcovitch, Philadelphia Branch; Kergan Wells, Toronto Branch. Chairman Nixon (picture on page 1017) completes the committee's roster.

FORTY-NINTH ANNUAL CONVENTION
AMERICAN ELECTROPLATERS' SOCIETY, INC.

SPONSOR:	American Electroplaters' Society, Inc. (AES), American Building, 443-445 Broad Street, Newark 2, New Jersey, and its 61 chartered American, Canadian and Australian Branches.
HOST:	The Midwest Regional Council of AES, including its Chicago, Milwaukee, Mississippi Valley, Rockford, St. Joseph Valley and St. Louis Branches.
SITE AND HOTEL:	Schroeder Hotel, Milwaukee, Wisconsin.
DATES:	June 24-28, 1962, in AES's fifty-third year.
ADULT REGISTRATION:	For male and female adults—$25 per person including Banquet, Outing, and all other AES official Convention events.
CHILDREN REGISTRATION:	For registered children—$15 per child, not including Banquet, but including three days of supervised sightseeing and children's program events, plus the Outing.
HOTEL ACCOMMODATIONS:	Order direct via Hotel Reservation Form to come to AES members in January 1962 from the Convention Committee via AES National Headquarters.
CONVENTION GENERAL CHAIRMAN:	Herman A. Tessmann (Milwaukee Branch), 3864 South 57th Street, Milwaukee, Wisconsin.
LADIES CHAIRMAN:	Mrs. John C. Auchter, 920 East Wye Lane, Milwaukee 17, Wisconsin.

GRAND OPENING SESSION • EDUCATIONAL PROGRAM • AES BOARD AND COMMITTEE MEETINGS • LADIES PROGRAM • CHILDREN'S PROGRAM • PLANT TOURS • DANCES • SIGHTSEEING • OUTINGS • UNIQUE CONCERT • SPONSORED RELAXATIONAL PROGRAMS • COCKTAIL PARTIES • GET-TOGETHER • GOLF TOURNAMENT • BANQUET • ENTERTAINMENT • FLOOR SHOW • ANNUAL BLUM LECTURE

Hotel Schroeder, Milwaukee, AES Convention Headquarters

City Hall is Milwaukee's tallest building

Milwaukee's New $8,000,000 Municipal Building

FINANCIAL REPORT

FOR THE TWELVE-MONTH FISCAL PERIOD JULY 1, 1960—JUNE 30, 1961

FOUNDED 1909

AMERICAN ELECTROPLATERS' SOCIETY, INCORPORATED
NEWARK 2, NEW JERSEY

We have examined the balance sheets of the General Fund and Research Fund of American Electroplaters' Society, Incorporated as of June 30, 1961, and the related statements of income and principal for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheets and statements of income present fairly the financial position of American Electroplaters' Society, Incorporated at June 30, 1961, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Newark, New Jersey
July 21, 1961

CLYDE A. ZUKSWERT & CO.
Certified Public Accountants

AMERICAN ELECTROPLATERS' SOCIETY, INCORPORATED

EXHIBIT A — **Comparative Balance Sheet—General Fund—June 30, 1961 and 1960**

ASSETS	June 30, 1961 "Society" Control	June 30, 1961 "Plating" Control	June 30, 1961 Total	June 30, 1960	Increase Decrease*
CURRENT ASSETS:					
Demand deposits	$ 3,425.83	$ 3,031.79	$ 6,457.62	$ 23,329.07	$16,871.45*
Petty cash	50.00		50.00	50.00	
United States Treasury Bonds:					
$10,000.00 Series K (redemption value)	9,780.00		9,780.00	9,740.00	40.00
$15,000.00, 3¼%, 6/15/83–78 at cost (market value $13,471.88)	15,682.20		15,682.20	15,682.20	
Time deposits	110,000.00		110,000.00	110,000.00	
Accounts receivable:					
Per capita tax				120.30	120.30*
Advertising, books, reprints, supplies and miscellaneous	415.82	3,526.29	3,942.11	3,850.94	91.17
Advances, conventions and exhibitions	1,000.00		1,000.00	2,000.00	1,000.00*
Due from Research Fund	162.49	46.00	208.49	472.17	263.68*
Accrued interest receivable	802.50		802.50	525.00	277.50
Prepaid expenses	838.26	1,812.20	2,650.46	7,608.97	4,958.51*
Total current assets	$142,157.10	$ 8,416.28	$150,573.38	$173,378.65	$22,805.27*
CONTRA ACCOUNTS:					
Due from "Society" control	$	$68,463.17	$ 68,463.17	$ 61,843.09	$ 6,620.08
Due to "Plating" control	(68,463.17)		(68,463.17)	(61,843.09)	6,620.08*
DEPOSIT, AMERICAN AIRLINES	$ 425.00	$	$ 425.00	$ 425.00	$
CARL E. HEUSSNER AWARD FUND:					
Fidelity Federal Savings and Loan Association, Glendale, California	$ 3,000.00	$	$ 3,000.00	$ 3,000.00	$
Totals	$ 77,118.93	$76,879.45	$153,998.38	$176,803.65	$22,805.27*
LIABILITIES AND PRINCIPAL					
CURRENT LIABILITIES:					
Accounts payable	$ 46.42	$ 94.91	$ 141.33	$ 6,409.05	$ 6,267.72*
Accounts receivable—credit balances		32.00	32.00	38.88	6.88*
Accrued expenses				15.00	15.00*
Deferred income	112.00	141.00	253.00	12.05	240.95
Total current liabilities	$ 158.42	$ 267.91	$ 426.33	$ 6,474.98	$ 6,048.65*
CARL E. HEUSSNER AWARD FUND	$ 3,000.00	$	$ 3,000.00	$ 3,112.35	$ 112.35*
GENERAL FUND PRINCIPAL, EXHIBIT D	$ 73,960.51	$76,611.54	$150,572.05	$167,216.32	$16,644.27*
Totals	$ 77,118.93	$76,879.45	$153,998.38	$176,803.65	$22,805.27*

NOTE: The policy of the Society is to charge all purchases of office furniture and equipment to expense.

COMPARATIVE STATEMENT OF INCOME
GENERAL FUND—"SOCIETY" CONTROL

EXHIBIT B — **For the years ended June 30, 1961 and 1960**

	Budget	Actual —Year Ended June 30,— 1961	1960	Increase Decrease*
INCOME:				
Membership Income:				
Per capita tax and dues (pro rata):				
Branch members	$31,000.00	$30,258.18	$30,853.02	$ 594.84*
Members-at-large	1,900.00	1,962.19	1,900.36	61.83
Sustaining members	900.00	841.05	870.75	29.70*
Sales:				
Publication sales (AES books):				
Technical Proceedings:				
Past editions	300.00	805.00	1,018.00	213.00*
1959 edition	1,500.00	1,347.00	6,637.50	5,290.50*
1960 edition	4,000.00	4,724.00		4,724.00
Glasstone book		532.36		532.36
Publication sales (non AES books)	4,500.00	8,049.85	7,240.44	809.41
Reprints:				
Technical Proceedings papers	2,000.00	1,319.91	2,478.39	1,158.48*
Sales to Branches:				
Membership insignia, etc.	300.00	365.00	345.86	19.14
Other Income:				
Interest on investments	5,000.00	5,456.62	5,300.38	156.24
Mailing services			988.32	988.32*
Miscellaneous		64.51	28.64	35.87
Total income	$51,400.00	$55,725.67	$57,661.66	$ 1,935.99*
Subsidy from General Fund	28,655.00			
Totals	$80,055.00	$55,725.67	$57,661.66	$ 1,935.99*
EXPENSES:				
Headquarters:				
Office operations (pro rata)	$ 7,200.00	$ 4,449.61	$ 4,163.50	$ 286.11
Postage and express		1,232.92	1,179.63	53.29
Printing, stationery and office expense		1,744.06	1,343.34	400.72
Furniture and fixtures (pro rata)	433.33	367.88	447.86	79.98*
Personnel salaries (pro rata)	28,333.33	27,747.30	20,267.82	7,479.48
Social security and hospitalization (pro rata)	1,066.66	799.71	652.04	147.67
Christmas fund	375.00	359.33	375.00	15.67*
Travel:				
Staff (pro rata)	2,833.33	2,112.58	2,575.56	462.98*
Elected AES officers	4,600.00	481.91	620.77	138.86*
Meetings:				
Committee meetings expense	750.00	520.00	345.81	174.19
Interim meeting, Supreme Society	1,250.00	558.26	378.37	179.89
Publishing:				
Technical Proceedings:				
Printing, engravings and mailing	23,000.00	19,343.88	24,863.79	5,519.91*
Promotion data	250.00	120.97	83.94	37.03
Postage		267.62	246.55	21.07
Blount electroplating primer	500.00	384.97		384.97
Reprints—Technical Proceedings articles	1,000.00	943.48	1,765.13	821.65*
Cost to sell:				
Glasstone book		428.76		428.76
Non AES books	3,000.00	5,729.40	5,546.41	182.99
Mailing service (Note 5)			746.10	746.10*
Branch supplies	300.00	454.59	336.23	118.36
Awards, convention expense, membership, manuals, convention proceedings, reporters, brochures, booklets, etc.	9,500.00	4,721.32	4,626.52	94.80
Total expenses	$84,391.65	$72,768.55	$70,564.37	$ 2,204.18
EXCESS OF EXPENDITURES OVER INCOME	$ 4,336.65	$17,042.88	$12,902.71	$ 4,140.17

NOTES:
1. The established custom, prior to July 1, 1959, was to charge cost of all reprints and to credit receipts from sales thereof, both to "Plating". Beginning July 1, 1959, "Technical Proceedings Reprints" expense and income were included in "Society" operations.
2. The Supreme Society has authorized withdrawal from the General Fund of an amount not to exceed $28,655.00 to balance the budget.
3. The policy of the Society is to charge all purchases of office furniture and equipment to expense.
4. Unallocable expenses for the year ended June 30, 1961 have been apportioned as follows: 33⅓%—"Society", 66⅔%—"Plating".
5. Mailing services transferred to "Plating" expense in 1960–1961.

COMPARATIVE STATEMENT OF INCOME
GENERAL FUND—"PLATING" CONTROL

EXHIBIT C — **For the years ended June 30, 1961 and 1960**

	Budget	Actual —Year Ended June 30,— 1961	1960	Increase Decrease*
INCOME:				
Subscriptions:				
Branch members (pro rata of per capita)	$ 14,000.00	$ 13,695.47	$ 13,949.45	$ 253.98*
Members-at-large (pro rata of dues)	500.00	490.56	475.09	15.47

EXHIBIT C (continued)

Sustaining members (pro rata of dues)	620.00	623.00	645.00	22.00*
Non-members	7,000.00	7,065.10	7,311.05	245.95*
Total subscriptions	$ 22,120.00	$ 21,874.13	$ 22,380.59	$ 506.46*
Sales:				
Advertising (except classified)	$	$153,065.83	$162,950.00	$ 9,884.17*
Less:				
Discounts allowed	$	$ 2,422.06	$ 2,578.36	$ 156.30*
Agency commissions		21,335.58	22,226.99	891.41*
Total deductions	$	$ 23,757.64	$ 24,805.35	$ 1,047.71*
Net advertising revenue	$150,000.00	$129,308.19	$138,144.65	$ 8,836.46*
Reprints, Plating magazine articles	3,000.00	2,337.02	3,740.88	1,403.86*
Classified advertising	450.00	372.20	648.40	76.20*
Direct mail service	1,500.00	1,051.81		1,051.81
Mart		1,976.35		1,976.35
Miscellaneous		1,049.92	1,069.79	19.87*
Total sales	$154,950.00	$136,295.49	$143,603.72	$ 7,308.23*
Total income	$177,070.00	$158,169.62	$165,984.31	$ 7,814.69*
EXPENSES:				
Headquarters:				
Office operations (pro rata share)	$ 14,400.00	$ 8,849.11	$ 8,253.13	$ 595.98
Postage		1,737.53	1,870.78	133.25*
Stationery, printing supplies		2,211.55	2,079.06	132.49
Furniture and equipment (pro rata)	866.67	735.65	223.95	511.70
Personnel salaries (pro rata)	56,666.67	55,495.18	60,792.52	5,297.34*
Social security and hospitalization (pro rata)	2,133.34	1,599.32	1,593.91	5.41
Commissions, advertising manager	2,200.00	907.45	1,646.38	738.93*
Travel:				
Staff (pro rata)	5,666.67	4,224.44	5,149.95	925.51*
Publishing Plating Magazine:				
Printing, engraving, art and other publishing expenses	84,000.00	77,729.32	75,910.25	1,819.07
Audit bureau of circulations and promotional advertising	3,800.00	2,767.68	2,575.05	192.63
Direct mail service	1,000.00	791.17		791.17
Reprints of Plating Magazine articles	2,000.00	1,527.61	2,626.84	1,099.23*
Total expenses	$172,733.35	$158,576.01	$162,721.82	$ 4,145.81*
EXCESS OF INCOME OVER EXPENSES	$ 4,336.65	$ (406.39)	$ 3,262.49	$ 3,668.88*

NOTES: 1. The established custom, prior to July 1, 1959, was to charge cost of all reprints and to credit receipts from sales thereof, both to "Plating". Beginning on July 1, 1959, "Technical Proceedings Reprints" expense and income were included in "Society" operations.

2. The policy of the Society is to charge all purchases of office furniture and equipment to expense.

3. Unallocable expenses for the year ended June 30, 1961 have been apportioned as follows: 33⅓%—"Society", 66⅔%—"Plating".

EXHIBIT D

STATEMENT OF GENERAL FUND PRINCIPAL
For the year ended June 30, 1961

	"Society" Control	"Plating" Control	Total
BALANCE, JULY 1, 1960	$89,818.39	$77,397.93	$167,216.32
ADDITION:			
Income from 47th Annual Convention, Los Angeles, California	1,685.00		1,685.00
Total	$91,503.39	$77,397.93	$168,901.32
DEDUCTIONS:			
Excess of expenses over income for the year ended June 30, 1961, per Exhibits B and C	$17,042.88	$ 406.39	$ 17,449.27
American Electroplaters' Society Scientific Achievement cash award authorized by the Supreme Society	500.00		500.00
Uncollectible advertising accounts written off		380.00	380.00
Total deductions	$17,542.88	$ 786.39	$ 18,329.27
BALANCE, JUNE 30, 1961	$73,960.51	$76,611.54	$150,572.05

EXHIBIT E

COMPARATIVE BALANCE SHEET—RESEARCH FUND
June 30, 1961 and 1960

ASSETS	June 30, 1961	June 30, 1960	Increase Decrease*
CURRENT ASSETS:			
Demand deposit	$ 38,386.00	$ 29,234.92	$ 9,151.08
Time deposits	84,000.00	84,000.00	
Accrued interest receivable	447.50	412.50	35.00
Totals	$122,833.50	$113,647.42	$ 9,186.08

EXHIBIT E (continued)

LIABILITIES AND PRINCIPAL

CURRENT LIABILITIES:			
Due to General Fund "Society" Control	$ 162.49	$ 330.17	$ 167.68*
Due to General Fund "Plating" Control	46.00	142.00	96.00*
RESEARCH FUND PRINCIPAL, EXHIBIT G	122,625.01	113,175.25	9,449.76
Totals	$122,833.50	$113,647.42	$ 9,186.08

COMPARATIVE STATEMENT OF INCOME—RESEARCH FUND

EXHIBIT F **For the years ended June 30, 1961 and 1960**

	Budget	Actual –Year Ended June 30,– 1961	1960	Increase Decrease*
INCOME:				
Sustaining membership dues and subscriptions (Pro rata share)	$30,000.00	$29,685.95	$30,734.25	$ 1,048.30*
Per capita tax (Pro rata share)	7,000.00	6,827.73	6,974.74	147.01*
Member-at-large dues (Pro rata share)	200.00	245.25	237.55	7.70
Branch contributions (American)		200.00	200.00	
Contributions (other societies)		500.00	500.00	
Sale of reprints	400.00	610.83	478.60	132.23
Interest on investment	3,000.00	3,495.00	3,428.75	66.25
Miscellaneous			.35	.35*
Total income	$40,600.00	$41,564.76	$42,554.24	$ 989.48*
Add: Appropriation from Research Fund Reserve	2,600.00	2,600.00	10,445.00	7,845.00*
Total	$43,200.00	$44,164.76	$52,999.24	$ 8,834.48*
EXPENSES:				
Payments to Canadian (Research Fund)	$ 7,300.00	$ 7,000.00	$ 6,560.00	$ 440.00
Payments to projects	30,250.00	20,350.00	32,442.43	12,092.43*
Reprints—Cost of serial reports, etc.	1,250.00	566.29	1,165.72	599.43*
Social security tax	100.00		26.89	26.89*
Travel expense	150.00			
Sustaining membership (promotion and certificates)	400.00	404.70	509.91	105.21*
Miscellaneous expense (including postage)	1,500.00	1,095.15	851.37	243.78
Office expense	2,000.00	2,000.00	1,500.00	500.00
Audit and contingency	250.00	112.00	141.00	29.00*
Foreign exchange fee		218.75	299.30	80.55*
1961 Research conference		368.11		368.11
Total expenses	$43,200.00	$32,115.00	$43,496.62	$11,381.62*
EXCESS OF INCOME OVER EXPENSES	$	$12,049.76	$ 9,502.62	$ 2,547.14

STATEMENT OF RESEARCH FUND PRINCIPAL

EXHIBIT G **For the year ended June 30, 1961**

BALANCE, JULY 1, 1960	$113,175.25	
ADDITION:		
Excess of income over expenses for the year ended June 30, 1961, per Exhibit F (includes appropriation transfer of $2,600.00)	12,049.76	
		$125,225.01
DEDUCTION:		
Transfer to budget income		2,600.00
BALANCE, JUNE 30, 1961		$122,625.01

STATEMENT OF RECEIPTS AND DISBURSEMENTS
CANADIAN RESEARCH FUND

EXHIBIT H **For the year ended June 30, 1961**

BALANCE, JULY 1, 1960 (THE DOMINION BANK, TORONTO, CANADA)		$ 2,516.25
RECEIPTS:		
American Electroplaters' Society, Research Fund	$7,000.00	
Sustaining membership dues	1,900.00	
Interest	32.34	
Total receipts		8,932.34
Total		$11,448.59
DISBURSEMENTS:		
Ontario Research Foundation	$9,000.00	
Taxes	4.85	
Total disbursements		9,004.85
BALANCE, JUNE 30, 1961 (THE DOMINION BANK, TORONTO, CANADA)		$ 2,443.74

NOTE: Research Fund, American Electroplaters' Society, Incorporated, has paid per capita tax to American Electroplaters' Society, Incorporated, for twenty Canadian members at $4.70 each.

INDICATE A 928.➤

LEA

ABRASIVE FINISHING METHODS

SILVER SOLID AND ALLOYS

STAMPINGS • SPINNINGS • CASTINGS

Of the noble metals silver is by far the most widely encountered in the metal finishing field. It is seldom used in the pure state but mainly in an alloy, such as sterling silver and, to a lesser degree, coin silver. As is commonly realized, the alloying elements, principally copper, are used to increase hardness and wear-resistance.

Because of the relatively high value of the metal, greater care is justified in devising the proper Lea Methods to see that metal losses in the finishing operations are kept to a minimum. The much higher price obtained for sterling silver articles justifies the greater finishing care.

Plated Silver, certainly an important subject, is discussed separately.

Following are the more widely used finishes for sterling and coin silver together with suggestions for producing them:

HAMMERED FINISH... Formerly, much silver was hammer-finished in order to refine the surface and because the alloys could be shaped readily by this method. The method is still used extensively, especially on reproductions. With hammering, of course, no silver is removed by abrasion.

DULL MATTE FINISH... With this finish, as well as with all the following finishes, the metal is first conditioned by "washing out" the pits by either spot sand bobbing or flexible polishing with **Grade "C" or Grade "B-31" Lea Compound** on leather or felt bobs. This step is usually followed by cut-down buffing with a Tripoli composition such as **Grade 765 Learok** and then by brushing at low speed with a suitable mixture of pumice and water.

DULL SATIN FINISH... Proceed as with the dull matte finishing up to but not through the pumice and water step. At that point, follow with a buffing step using **Grade "C" or Grade "B-31" Lea Compound,** whichever is better, at a speed of about 5000 sfm.

BUTLER FINISH, SEMI-BRIGHT TO BRIGHT... Follow the steps given under dull matte finish up to and including the **Grade 765 Learok** cut-down. Then proceed with the final finishing operations, using **Fine Silver grades of Lea Compound,** such as **Grades MH, B12 or 5023,** to give the desired butler finish. Full-disc or packed muslin buffs are used at 7000 to 7500 sfm.

SEMI-MIRROR FINISH... Proceed as with the dull matte finish, through the **Grade 765 Learok** cut-down step. Then follow with coloring, using either **Grade 302-C or Grade 884 Learok** on a loose muslin buff at 7500 sfm.

Where automatic buffing is being done **Grade TH52P Lea Liquabrade** is used for a cut-down operation and **Grade UH20A Liquabrade** for coloring.

MIRROR FINISH... Proceed as with the semi-mirror finish except use **Lea Red Rouge A100 Bar Compound** or **Grade 63LR Liquid Rouge.**

ULTRA-MIRROR FINISH... Proceed as with the mirror finish and follow with lamp black and kerosene.

THE LEA MANUFACTURING CO.

16 CHERRY AVE., WATERBURY 20, CONN.

Lea-Michigan, Inc., 14459 Wildemere, Detroit 38, Mich.
Lea Mfg. Company of Canada, Ltd., 1236 Birchmount Road, Scarborough, Ontario, Canada
Lea Mfg. Co. of England, Ltd., Rock Terrace, Buxton, Derbyshire, England
Lea-Ronal, Inc. Main Office and Laboratory: 130-19 180th St., Jamaica 34, N.Y.
Manufacturing Plant: 235 East Aurora St., Waterbury 20, Conn.

Burring, Buffing, Polishing, Lapping, Plating and Spray Finishing . . . Manufacturers and Specialists in the Development of Production Methods, Equipment and Compositions. Manufacturers of Lea Compound and Learok . . . Industry's quality buffing and polishing compounds for over 30 years.

LEA®

The Hallmark of Quality Products

Are you interested in plating specialties? ***SEE THE OTHER SIDE OF THIS INSERT***

AURALL GOLD* (24K)

passes the toughest nitric acid test

Pieces . . . . . electrical connectors
Plate . . . . . 100 millionths of an inch
Place . . . . . customer's plant
Test . . . . 30 minutes in boiling concentrated nitric
Results . no sign of corrosion or attack on base metal

Comparative tests on parts plated with same thickness of gold from both conventional cyanide and acid golds showed complete attack of the base metal in less than 10 minutes.

Make this simple comparative test with your own gold plate and see the advantages the Aurall Gold offers you. It is possible to obtain complete protection with lesser thickness of plate with Aurall Gold, thereby saving in gold.

Aurall Gold will provide not only the answer to simplification of your plating operations but substantial improvements in corrosion protection, freedom from porosity, and the ability to withstand high temperatures without discoloration.

Full details will be sent promptly on request.

OTHER AURALL GOLD FEATURES

- ★ Bright to lustrous, all-inclusive 24K gold plating process.
- ★ Exceptional resistance to high temperature discoloration.
- ★ Meets critically exacting industrial and scientific requirements where high degree of ductility, freedom from porosity and excellent solderability are required.
- ★ Completely stable bath; operable over a wide temperature range; excellent throwing power.
- ★ Combines advantages of cyanide and acid baths in one solution that does not deteriorate with age or in prolonged operation.
- ★ Simple to operate; easy to control.

*Patents pending

The LEA GROUP
serving the Finishing Field
Lea-Ronal, Inc., Jamaica, N. Y.
Lea-Michigan, Inc., Detroit
The Lea Mfg. Co., Waterbury, Conn.
Lea Mfg. Co., of Canada, Ltd.
Lea Mfg. Co., of England, Ltd.
Plating Polishing Buffing Burring

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Are you interested in Buffing, Polishing and Burring Specialties? **SEE OTHER SIDE OF THIS INSERT.**

INTERSOCIETY NEWS

ASTM COMMITTEE PLANS SYMPOSIUM ON ELECTROFORMING

Encouraged by the marked success achieved in 1956 when ASTM Committee B-8 sponsored a Symposium on Electroplated Coatings, this same committee now plans a Symposium on Electroforming. The event, which will schedule 12 papers to be presented at three sessions, will occur during ASTM Committee Week in Dallas, Texas, in early February 1962.

With A. D. Squitero acting as co-chairman, the Symposium is being organized by W. L. Pinner, who also arranged the one held in 1956. The program is in the advanced planning stage and will include papers on electroforming solutions, properties of electroformed deposits and the practical application of electroforming in the manufacture of essential products used in diverse industries such as automotive, space vehicle and the recording field.

Details of the exact program will be published at a later date. It is expected that the meeting will attract considerable interest, especially among engineers producing or using the products of the electroforming industry.

♦

BLACK NAMED TO NATIONAL METAL TRADES POST

James M. Black has been appointed executive vice president of National Metal Trades Association to succeed George Earl who will be retiring after 33 years of service. Composed of more than 1200 manufacturers, the association's headquarters are in Chicago with branches located in industrial centers of the country.

A graduate of the University of South Carolina and Princeton University, the author of books and articles on labor relations and management development programs, Mr. Black has been associated with the Pennsylvania Railroad, American Management Association, and Associated Industries of Cleveland.

♦

NAMF COMMITTEE CHAIRMEN ANNOUNCED

Edward N. Marlette, president of the National Association of Metal Finishers, has named 13 industry leaders to top NAMF committee posts. The appointments, of one year's duration, are effective at once. Individual committee members will be appointed in the next few weeks.

The new chairmen: educational, W. R. Crawford, Chrome-Rite Corp., Chicago; membership, constitution and bylaws, James E. Cogan Jr., Globe Electroplating Co., Philadelphia; public relations, Harold E. Coombes Jr., Crown City Plating Co., El Monte, Calif.; government liaison, Jerry Burton, Burton Silverplating Co., Culver City, Calif.; standards, Henry A. Kafarski, Chemical Processing, Inc., Detroit; labor relations, Glenn H. Friedt Jr., United Platers, Inc., Detroit; ethical practices, John T. Hyduke, Durable Plating Co., Cleveland; trade tour, Jules Horelick, Allied Metal Finishing, Baltimore; liaison, American Electroplaters' Society, A. T. Leonard, Superior Plating, Inc., Minneapolis; liaison, Metal Finishing Suppliers' Association, Robert L. Giesel, Adolph Plating, Inc., Chicago; budget and finance, A. T. Leonard, Jules Horelick; Frank Kaiser, Long Island Mechanical Plating Co., Woodside, N. Y.; Sal Novelli, Service Plating Co., Brooklyn; and Mariano Ranno, Imperial Plating, Inc., Brooklyn; and industry liaison, Charles R. Leva, Levco Metal Finishers, Inc., Long Island, N. Y.

♦

QUALITY CONTROL CONFERENCE AT ST. LOUIS

Richard S. Bingham Jr., manager, quality control, the Carborundum Company, Niagara Falls, N. Y., will be among the principal speakers at the 16th Midwest Conference of the American Society for Quality Control, October 19–20, at the Hotel Chase-Park Plaza, St. Louis, Mo.

Mr. Bingham will discuss "What's Behind Experimental Design," describing the use of statistics to get the maximum amount of information from each experiment.

The ASQC is a national organization which encourages the development of statistical techniques to improve quality control in our nation's industrial processes. The Midwest Conference is part of its continuing program for the interchange of valuable information.

♦

FRENCH LICK SITE OF CERAMIC SOCIETY MEETING

The Enamel Division of The American Ceramic Society will hold its first fall meeting at the spacious French Lick-Sheraton Hotel, French Lick, Ind., September 20–23.

Concerned with ceramic-metal interactions, the Enamel Division's technical program will deal with high temperature protective ceramic coatings, ceramic-metal composites, ceramic coatings as adhesives, flame-sprayed ceramic and cermet coatings for metals, and ceramic coatings of dielectrics. Nineteen papers have been organized by division chairman Loran S. O'Bannon, Battelle Memorial Institute, and program chairman R. S. Sheldon, Whirlpool Corp.

TECHNICAL SOCIETIES AND ASSOCIATIONS TO PARTICIPATE IN METAL SHOW

A record number of ten American technical societies and trade associations, with a combined membership of more than 100,000 will present 62 half-day technical sessions at the Detroit Metal Show in participation with the sponsoring American Society for Metals, October 23–27. The technical program will run concurrently with presentation of ASM's educational exhibit on materials and materials processing at Cobo Hall.

Major part of the technical program will be presented by the ASM, involved in 31 half-day sessions; Metallurgical Society of AIME, 23 sessions; and Society for Nondestructive Testing, 8 sessions.

Presenting joint sessions with ASM in addition to AWS and AGA are Industrial Heating Equipment Association, Metal Powder Industries Federation, Metal Treating Institute, Special Libraries Association and Ultrasonic Manufacturers Association. For the first time, exhibits and technical sessions of all except AIME will take place under one roof, thanks to completion of Detroit's new Cobo Hall facility.

♦

METAL TREATING INSTITUTE AT METAL SHOW

For the first time in its history, the Metal Treating Institute, the national trade association of the commercial heat treating industry, is having an exhibit booth at the ASM Detroit Metal Show, the 43rd national Metal Congress and Exposition being held in Cobo Hall, October 23–27.

Booth No. 515 will be staffed by the personnel of the seven member companies participating in this cooperative exhibit to promote the use of commercial heat treating services to industry.

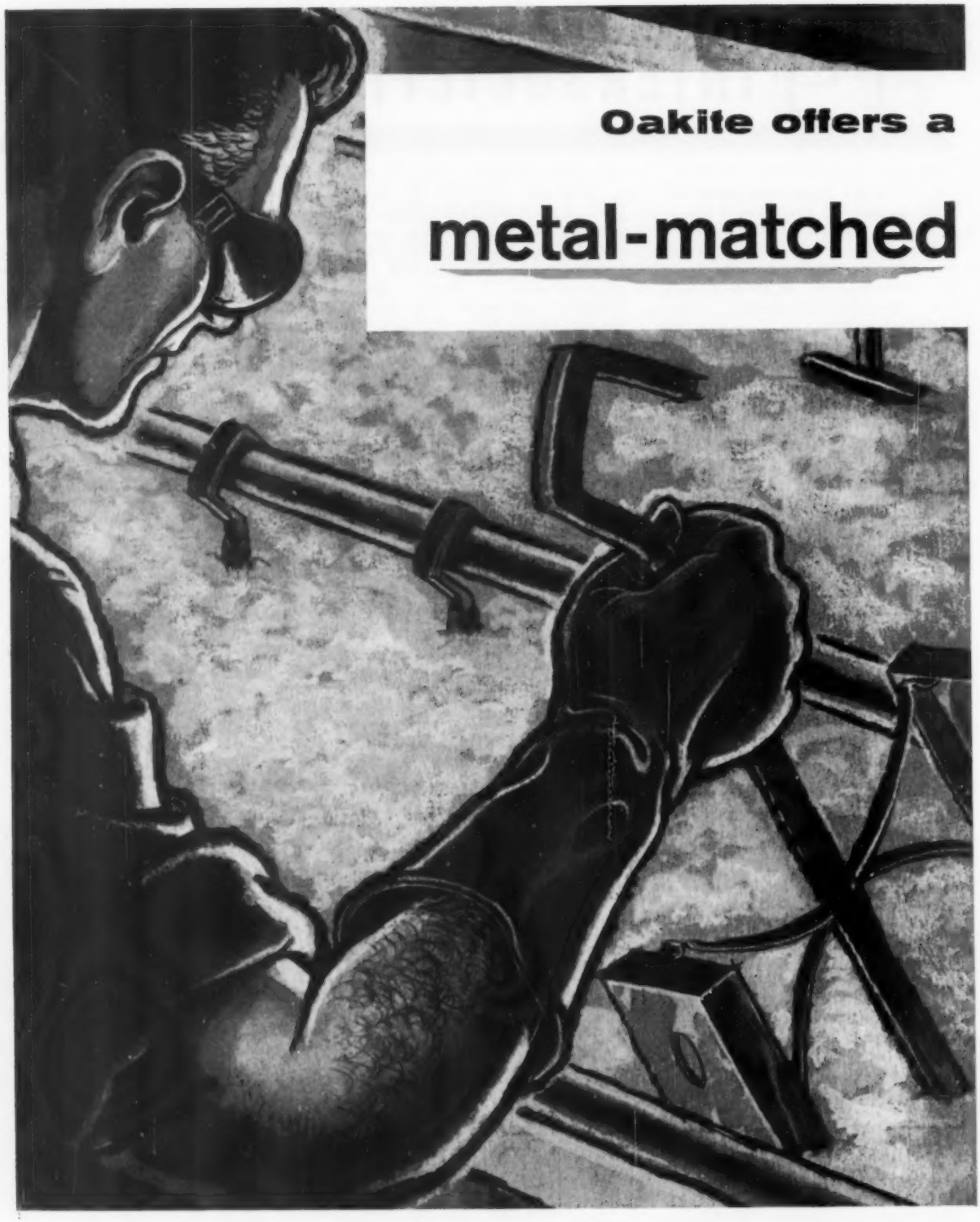
♦

AIChE MEETING WILL STRESS MANAGEMENT

Lake Placid has been selected as the site for the 46th National Meeting of the American Institute of Chemical Engineers, in the Lake Placid Club, September 24–27. Management will be the theme of the meeting. It is expected that 2000 chemical engineers from all parts of this country and Canada will attend.

B. I. MacDonald Jr., General Electric Company, Waterford, N. Y., has been named general chairman. E. R. Smoley, Scarsdale, N. Y., is the technical program chairman.

INDICATE A 929



Oakite offers a

metal-matched

For the complete answer to better plating

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS

complete line of materials for

ELECTROCLEANING

. . . improves the cleaning
. . . improves the plated-work

There are Oakite electrocleaners to meet the special requirements of all the usual basis metals being plated, and the soils generally left on the parts during fabrication operations.

Matched to the work, each electrocleaner does the job with remarkable efficiency and surprising economy. Service results show it. Users find that solutions have long life. Operating problems are at a minimum. Most importantly, a metal-matched electrocleaner assures a brighter and perfectly adhering plated finish.

TWO-IN-ONE CLEANING OF STEEL

Oakite 190 does double duty. A *chelated* detergent for anodic or periodic reverse current use, it removes smut, heat scale and rust bloom that normally need extra treatment. At the same time, its powerful alkaline detergency gets rid of oil films and shop soil. Such cleaning insures fewer plating rejects, and can in many cases eliminate an entire operating step.

CLEANING OF COPPER WITHOUT TARNISH

Oakite 191 gives fast, thorough electrocleaning action on brass and other copper alloys, while protecting against tarnish . . . especially in reverse current cleaning. Shop soils, smuts, light buffing compounds disappear quickly. For heavily soiled parts, the solution also serves as a non-tarnishing pre-soak.

FEWER REJECTS FOR ZINC DIE CASTINGS

Oakite 195 electrocleans without etching or discoloring buffed zinc base die castings . . . also works well with lead, brittania metal, steel and brass. Used with direct, reverse or periodic reverse current, it removes soils safely yet thoroughly . . . assuring a brighter chromium luster. Many users of this new cleaner have reported no rejects due to poor electrocleaning for the first time in their experience.

Ask Oakite to detail what's in store for you when you match these materials to your work. Write Oakite Products, Inc., 40 Rector Street, New York 6, N. Y.

it PAYS to ask . . . **OAKITE**

over 50 *years' leadership in industrial cleaning* — *Est. 1909* — SCIENCE

Media-matched compounds offer better barrel finishing

A good match of compound to the job means clean and efficient media . . . faster cutting down, deburring . . . and proper lubrication for smooth burnishing. Oakite can match your needs with compounds for fine finishes, tight tolerances - for hard or soft water. Send for Bulletin F-9339.

Stop spotting, add sparkle with Oakite Rinsite®

After plating and barrel finishing, adding a little Rinsite to rinse water, helps cut water spotting and staining. It "thins" the rinse, makes it drain faster. It also leaves a thin, non-oily, invisible film that adds sparkle and indoor rust protection to plated parts. Send for Bulletin F-9822.

INDUSTRY NEWS

MAAS & WALDSTEIN CELEBRATES 85th BIRTHDAY

Established in 1876 by New York businessmen Adolph Maas and Adolph Magnus and British chemist Dr. Martin L. Waldstein, the Maas & Waldstein Company, Newark, N. J., Chicago and Los Angeles, in the course of 85 years has created no less than 50,000 industrial finishes to maintain and protect the creations of modern industry and technology.

The development of Maas & Waldstein Co. parallels the scientific and industrial advances that followed the Civil War and has shown no sign of letting up since. The company did not start out as a synthesizer and producer of paints and finishes. The original interest lay in the field of industrial and purified chemicals for the plating, jewelry and other industries. But with the production of new machinery to handle work formerly done by hand and with the use of new untried products of every description, a critical need arose for equally new and revolutionary industrial finishes that could do the job of economically finishing, beautifying and protecting the creations of man's imagination. Maas & Waldstein Co. found itself in the industrial finishes business.

The company's original plant in New Jersey—still in use—was repeatedly enlarged over its first 40 years in an effort to keep pace with its expanding research and production requirements. By the beginning of World War I, it became apparent that even with enlargements one plant was inadequate to handle wartime volume. The company set about building a second plant, in the Port Newark area. In 1923, the company opened a warehouse, mixing plant and office in Los Angeles, Calif., to service burgeoning West Coast manufacturers. A year later, an office, plant and laboratory were opened in Chicago.

The research and development of new finishes for new metals and materials proceeded ever more swiftly during the next 15 years, and sales of Maas & Waldstein Co. increased considerably. In 1939, the company made its first acquisition: the Essex Chemical Company of Newark, an old and respected producer of industrial finishes with an experienced sales force and established clientele.

Six years later, in 1945, Maas & Waldstein Co. made its second acquisition: the Smith-Davis Company of Los Angeles, a company with a manufacturing plant supplying western states customers with organic coatings.

World War II necessitated a reorganization and conversion of Maas & Waldstein's production facilities to meet the nation's defense needs. While nitrocellulose was no longer critical to a war fought with bazookas and bombers, specialized lacquers and synthetic enamels were. For four years the company devoted its research and development efforts to the specialized equipment needs of the armed forces, and its record during that period provides one of the proudest chapters in the company's history.

Under the leadership of its president Dr. Gustave Klinkenstein, who joined the company as a chemist in 1916, Maas & Waldstein Co. has pioneered innumerable breakthroughs in the field of industrial finishes. Among the most important has been the development of metallic colored enamels and clear lacquers in response to industry's need for coatings of exceptional durability and toughness, and multicolored

Dr. G. Klinkenstein

textured coatings, which added a new dimension to the art of interior decoration.

With the celebration of its 85th year in business, Maas & Waldstein Co. looks ahead to a future infinitely more exciting than its colorful past. The revolution in the production of new and synthetic materials is still in its infancy. Out of the laboratories of the world are emerging space-age products never conceived of before except in the imaginations of science-fiction writers. Their maintenance and protection against unknown elements will require new dimensions of scientific imagination and creativity.

♦

ELECTROCHEMICAL MACHINING PROCESS LICENSED TO H-VW-M

An electrochemical machining process, initially developed by General Electric Company, is now being readied for extensive commercial use by Hanson-Van Winkle-Munning Company under GE license. The new process is applicable to all metals and will find particular use in machining the modern alloys used in the space and nuclear programs.

The process permits stress-free machining of complex contours in any metal, including the refractory alloys, in a single operation. The process also makes it possible to hold extremely close tolerances.

Electrochemical machining makes significant savings in metal removal operations possible at a relatively low capital investment cost. The process was developed at General Electric's Flight Propulsion Division near Cincinnati to machine jet engine components.

The ECM process is essentially the reverse of electroplating. The work piece and a so-called "cutting tool" shaped like the desired part serve as electrodes. A high amperage direct current is passed through the work piece to the "cutting tool," through an electrolyte, shaping the raw stock into the finished product.

The process is applicable to all metals. Highly complex shapes and extremely

At Western Electric

MEAKER AUTOMATIC DELIVERS CONSISTENT QUALITY ZINC PLATING FOR MILLIONS OF SWITCH PARTS

How large the world? No more than the minutes it takes to telephone *anywhere!* A pioneer in communications is the Western Electric Company which builds years of rugged service into every piece of telephone equipment produced at its extensive Hawthorn Works, Chicago. Superior performance is a never-ending quest of Western Electric production engineers.

The Meaker "Automatic" was chosen and installed four years ago to zinc plate switch mounting plates and relay covers. These are parts of busy telephone central offices—the communication nerve centers of offices and factories throughout the United States.

Since 1899, Meaker engineers have been building automatic metal processing equipment. These range from units tailor-made to fit limited floor space and handle modest output to the largest plating installation in the world!

Whether large or small, every Meaker is made to save its owner money—through lower labor costs, greater plating uniformity and greatly improved product quality. Send for our new catalog "When to Automate" which will give you some valuable ideas on improving your profits—and products—through automatic plating or metal finishing.

SINCE MEAKER 1899

THE MEAKER COMPANY

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close tolerances (± 0.0005) are said to be achievable, and both minute and massive machining are claimed to be possible. Machining costs are expected to be favorable, particularly on difficult-to-machine metals.

GE forecasts that within five years, a complete line of electrochemical machines will be on the market. In addition to the licensing of several General Electric patents, the agreement calls for the transfer of GE know-how through the training of Hanson-Van Winkle-Munning personnel.

♦

SIGMUND COHN ORGANIZES CALIFORNIA CORPORATION

In order to accelerate service to West Coast customers Sigmund Cohn Corporation has recently organized the Sigmund Cohn Corporation of California, 151 C. North Maple Street, Burbank, California. The new organization will handle the various lines of electroplating solutions, wire, sheet and other products of Sigmund Cohn Corporation and its affiliates, Sigmund Cohn Mfg. Co., Inc. and Pyrofuze Corporation. These products are all manufactured in the corporation's plant at Mount Vernon, N. Y.

F. Karg

Fred Karg, a man of long technical experience, is in charge of the California office. He received his technical training at the Newark College of Engineering and at the University of Southern California. Prior to his connection with the Sigmund Cohn Corporation of California Mr. Karg was, for many years, associated in an engineering capacity with one of the West Coast's well-known instrument manufacturers.

Charles P. Covino, right center, president of General Magnaplate Corp., Belleville, N. J., has been elected 1961–62 chairman of the Metropolitan Chapter of the Society for Nondestructive Testing. Mr. Covino is also president of the Theoretical Institute of Advanced Design, Inc., and is a member of the American Electroplaters' Society. Alfred E. Feldt, outgoing chairman, presented the gavel. Also shown, Ben Hoitsman, secretary, and Ross S. Peterson, vice chairman.

(Continued on page 1054)

ULTRASONIC CLEANING

CUTS REJECTS TO LESS THAN ¼%

A rack of precision reflectors is removed from a side-mounted ultrasonic tank at the Foremost Manufacturing Co.

Mr. Herb Schiller of Foremost Manufacturing Co., Maplewood, N. J., manufacturers of precision metal reflectors states: "Since we installed Branson ultrasonic cleaning equipment our rejects have been reduced from 8% to less than ¼%. Our ultrasonic cleaning equipment is extremely reliable. Branson's excellent service has certainly helped to make our operation even more efficient."

Ultrasonic cleaning achieves a high degree of cleanness far beyond the range of other methods. Although cleanness is still important, there are additional advantages to ultrasonic cleaning. These are:

- Reduced cleaning time
- Cost reduction through labor savings
- Process simplification

Whether your products are small or large, simple or complicated, you owe it to yourself to investigate the use of ultrasonic equipment for your company. Branson's highly experienced, factory-trained specialists stand ready to assist you anywhere in the U. S. Tell us about your particular problem and Branson's engineering department shall try to find the **best** possible solution in the **shortest** possible time.

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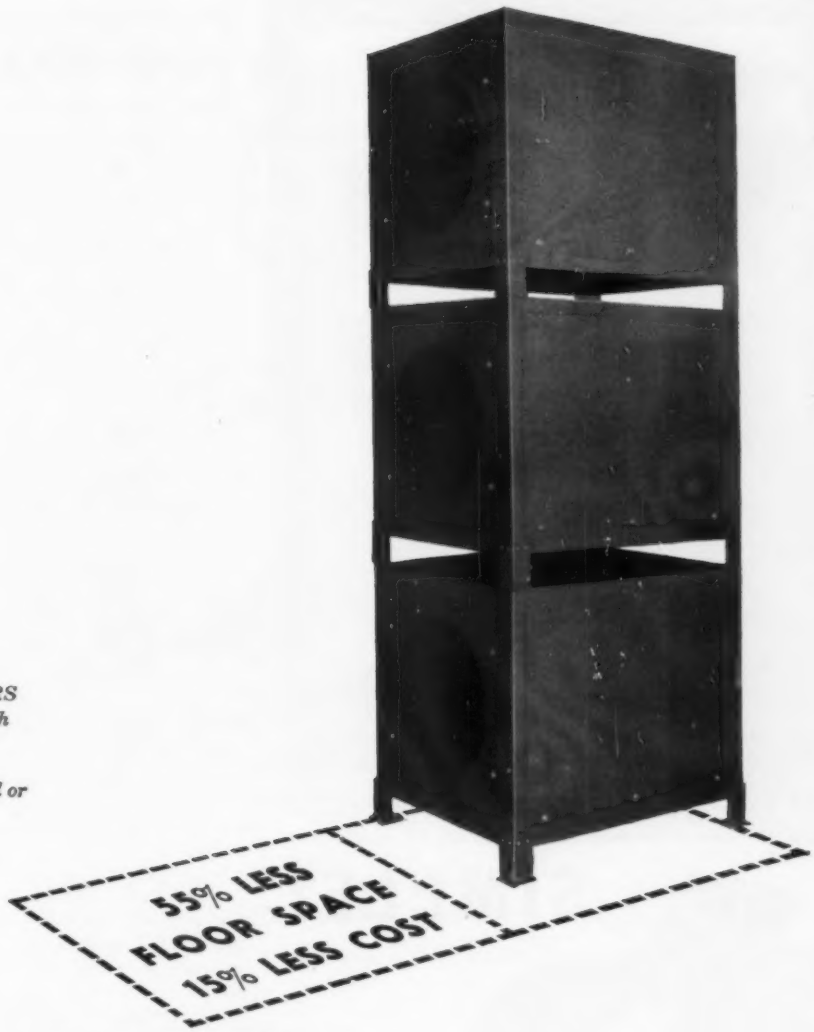
A bonafide example of the advertiser's proposed mailing must first be received and screened by PLATING. If mailing assignment is accepted thereby, the entire quantity must be shipped by the advertiser to PLATING MAGAZINE's Newark, N. J. office, pre-stuffed, for PLATING addressing and mailing. No mailing of less than a thousand pieces is acceptable. For further, fuller details, including costs, write or call Thomas W. Lowe, Production Manager, PLATING MAGAZINE, American Building, 443-445 Broad Street, Newark 2, N. J. (Telephone HUmboldt 2-3400).



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You can build your own capacity with Allied Compacts. Use any combination of 1000 to 3000 ampere building block units side by side or stacked up to meet present or future needs.

Get full details on Allied Compact Rectifiers from your Allied representative today. He's listed in the Yellow Pages under "Plating Supplies". Or, write direct.

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INDUSTRY NEWS BRIEFS

CONVERSION CHEMICAL LICENSES REPRESENTATIVE IN GERMANY

Conversion Chemical Corporation, Rockville, Connecticut, has completed arrangements with Dr. Ing. Max Schlötter, Geislingen/Steige, Germany, as licensees for Kenvert Products in Germany and "The Common Market."

The Schlötter organization has been identified for many years as suppliers to the metal finishing trade, and are actively engaged in production of equipment and materials to all phases of the industry.

Kenvert treated products were displayed in the Schlötter booth at the Hanover Fair in Germany this Spring, with a gratifying response from the trade. Kenneth Bellinger, president of Conversion Chemical, recently returned from a trip to Germany and England, visiting the Schlötter organization and the English licensee, Silvercrown Limited.

At Geislingen/Steige discussions were held with the manufacturing, laboratory, and sales staff regarding all phases of manufacturing, production, and application of Kenvert products to metal surface treatments. In England, at both London and Birmingham, sales meetings were held with the Silvercrown organization covering new developments in the processes, and several customer plants were visited.

♦

PLATRONICS REPRESENTED THROUGHOUT NATION

With negotiations for representation on the West Coast completed, Platronics, Linden, New Jersey, precious metals platers for the electronics industry, announces they are the first enterprise of its kind to offer nation-wide representation and local technical assistance throughout the country.

According to John Palumbo, secretary and general manager, the credentials of hundreds of manufacturers' representatives were screened, and dozens of interviews were conducted over the past year. "We wanted to avoid mere contact men and physical coverage of territories alone", Mr. Palumbo stated. "We appointed only those representatives organizations qualified to provide technical assistance as well."

♦

GEOSCIENCE MOVES TO LARGER HEADQUARTERS

Geoscience Instruments Corporation is moving to substantially larger facilities at 110 Beekman Street, New York 38, N. Y. The new headquarters will accommodate Geoscience's new laboratory. The premises are divided into clean rooms in which the company will fabricate and finish metals, ceramics and exotic materials. The laboratory is also equipped to do research work on metals and ceramics.

YOUR PLATING MAGAZINE QUESTIONNAIRE

So as to assure that PLATING MAGAZINE's classification of its subscribers by number, function and geographical location is constantly and consistently up to date for Audit Bureau of Circulations audit, a Return Sheet was recently issued to each subscriber internationally. It is revealing that nearly 50 per cent of such Return Sheets issued were executed and returned by subscribers within ten days of issuance, with the flow, of course, continuing. If you have not yet accomplished and returned yours, your cooperation in doing so promptly will be appreciated by AES and PLATING.

USE READER SERVICE CARD; INDICATE A 935.

ISOBRITE® 354 Zinc Plating Brightener

Unretouched photograph illustrates Isobrite 354's ability to give a sparkling finish to deep recesses and unusual shapes as well as flat surfaces.

Why does Isobrite 354 give you the most for your money? Let's see:

VERSATILITY—Isobrite 354 works at top efficiency over the lowest to highest current density ranges, giving you an extra bright finish in either rack or barrel operations.

ECONOMY—You get from 85,000 to 125,000 ampere/hours per gallon brightening life from Isobrite 354, depending on the degree of brightness you require. (And, if you're after a *permanent* full bright effect, use Iridite as a final finishing process.)

THROWING POWER—It's the ability to get into recesses—deep, narrow recesses—as well as giving a high luster on flat, easily accessible surfaces — that makes Isobrite 354 the right brightener for you. Flat, convex, concave surfaces—turns, twists or loops — Isobrite 354 covers any surface.

STABILITY—Isobrite 354 has exceptional high temperature stability . . . and it bounces right back to full effectiveness even after long, weekend shutdowns.

Call your Allied Field Engineer for complete information on Isobrite 354 or other Isobrite brighteners for zinc, cadmium and copper. He's listed in the Yellow Pages under "Plating Supplies". Or, write direct for technical data. On the West Coast, write or call the L. H. Butcher Co., licensee.

New Isobrite Pak with Flex-Spout gives pouring, storing and handling ease

Unscrew the cap and pop out the spout for non-drip pouring and accurate measuring. Pop the spout back in for safe, convenient handling. Spout, polyethylene container all packaged in a square, lightweight cardboard container to make storing and inventory easy.

FREE BOOKLET—"Practical Cyanide Zinc Plating". Gives practical information for purchasers and users of zinc plating processes. Tells how to produce quality work efficiently and economically. Direct requests to Department 2 of address below.

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PATENT ABSTRACTS

DR. D. GARDNER FOULKE
SEL-REX CORPORATION
Nutley, New Jersey

Copies of patents may be obtained by writing to Commissioner of Patents, Washington, D.C. Price 25 cents each.

2,976,169, 3/21/61—IMMERSION TIN—M. Streicher, assignor to E. I. du Pont de Nemours & Co., Wilmington, Del.

To make a selected area of a steel sheet amenable to soldering, roughen the area, then deposit tin on the area from an aqueous solution of

	Parts by weight
Water	2400
Stannous sulfate	30 ± 18
Sulfamic acid	270 ± 50
Polyalklene oxide (350–20,000)	48 ± 16

2 claims.

♦

2,976,170, 3/21/61—ALUMINUM SURFACE TREATMENT—E. Eiland, assignor to Aluminum Co., of America, Pittsburgh, Pa.

Aluminum having residual oil thereon can be made receptive to adhesively applied cratings if treated by treating the surface with phytic acid.

11 claims.

♦

2,976,171, 3/21/61—GLASS COATING STEEL—J. Sullivan, assignor to A. O. Smith Corp., Milwaukee, Wis.

Grit blast the steel to a RMS of 230–450 micro-inches, deposit 0.08 to 0.30g of nickel/sq ft of steel surface. Apply a vitreous enamel composition to the nickel and fire.

3 claims, figure.

♦

2,976,180, 3/21/61—ELECTROLESS SILVER—R. Brookshire, assignor to Hughes Aircraft Co., Culver City, Calif.

A hypophosphite—silver cyanide—alkali metal cyanide solution for plating silver by reduction is described.

See also 2,976,181 describing a similar gold plating deposition method with 4 claims.

4 claims.

2,976,193, 3/21/61—ALUMINUM COATING TREATMENT—G. Pimbley, assignor to Purex Corp., Ltd., California.

Claim 6 reads: "A process for producing a substantially colorless chemically bonded coating on an aluminum article, which comprises treating said article with an aqueous acid aluminum conversion coating bath, said bath comprising a halogen-containing anion, an anion including a member of the group consisting of hexavalent chromium, molybdenum, tungsten and ferricyanide, a cation of the group consisting of zinc, cadmium, mercury, vanadium, chromium, manganese, iron, cobalt, nickel and copper, and an agent of the group consisting of a soluble thiocyanate, a soluble cyanate, thiourea, urea, cyanuric acid, thiocyanuric acid, soluble sulfur-containing compounds, soluble phosphorus-containing compounds, soluble ferrocyanides, soluble divalent and trivalent chromium compounds, hydro-quinone, quinhydrone and hydrazines, and forming a substantially colorless conversion coating of high corrosion resistance, the *p*H of said solution being about 1.5 to about 3.5."

♦

2,976,194, 3/21/61—IMPROVING REFRACTORY METALS—M. Commanday and J. Darnell, assignors to Chromizing Corp., Delaware.

A method of surface decontamination and improvement of physical properties of the refractory metals W, Mo and their alloys consists in placing said alloys in a closed zone in contact with a diluent, 5 to 50 per cent of the powdered refractory metal and 0.05 to 0.5 per cent of ammonium halide at elevated temperature for 4–24 hours.

8 claims.

♦

2,976,225, 3/21/61—NICKEL PLATING—D. Foulke, W. Stoddard, O. Kerdos, W. Kleiner, assignors to Hanson-Van Winkle-Munning Co., Matawan, N. J.

The use of 3-bromocoumarin in nickel baths to provide a smoother, corrosion-resistant deposit is claimed.

1 claim.

♦

2,978,355, 4/4/61—METHOD AND APPARATUS FOR COATING METALS—A Busch, Kirchstrasse, Weissenthurm, Germany.

An apparatus for hot dipping steel strip in the presence of an inert gaseous medium at the exit end.

12 claims.

♦

2,978,370, 4/4/61—TINNING—J. Mulholland, assignor to L. Gary, Cleveland, Ohio.

A combined fluxing, cleaning and tinning device making use of a synthetic sponge is described.

6 claims.

Zialite
Reg. U. S. Pat. Off.
for NICKEL PLATING
DIRECTLY on ZINC DIECASTINGS, Aluminum, Brass, Copper, Lead, Iron, and HYDRO-T-METAL.
TREMENDOUS THROWING POWER, COVERS SMOOTHLY parts made up of several metals.
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Harder CRACK FREE deposits. Increased throwing power. Less sensitivity to sulfate content. Exceptionally fine results plating anything calling for Decorative or Hard Chrome.
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"GOLDEN TACKY"
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Provides firmer buff body • Eliminates loose, frayed fibre ends • Increases buffs ability to hold compound • Makes buffs wear longer and cut harder • Gives better finishing in fewer passes
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"By plating this part with LEVELUME 220 we slashed polishing time in half"

says JOSEPH T. HINES, Plant Manager, Southern Finishers, Inc., Nashville, Tenn.

A 50% reduction in the time it takes to polish this griddle cover is only *one* of the reasons Southern Finishers, Inc., is so enthusiastic about Levelume 220. This plater of some 500 different parts has cut polishing time one-quarter in *over-all* operations. Copper plating and copper buffing have been done away with on the griddle part and many others—saving up to two steps in seven.

"Appearance is better, too," says Joe Hines, a plater for 16 years. "Levelume 220 hides scratches nicely, plates brighter in recessed areas than any bath I've ever seen."

Southern is plating parts from ½-inch faucet buttons to 64" x 25" wire racks. What will Levelume 220 do on what *you're* plating? Ask H-VW-M.

H-VW-M *Progress in metalfinishing through advanced processes • equipment*

Hanson-Van Winkle-Munning Company, Matawan, New Jersey • Offices in Principal Cities
Alert Supply Company is H-VW-M in the West • Los Angeles • San Francisco

FOR FURTHER INFORMATION, USE READER SERVICE CARD; INDICATE A 937.

TRADE LITERATURE

L—901. ANODES AND PLATING CHEMICALS—Hanson-Van Winkel-Munning Company has just made available a two-color, eight page bulletin No. AC-113 illustrating and describing the full line of H-VW-M anodes, anode accessories and chemicals for electroplating and metal-finishing.

Nickel, cadmium, brass and bronze, copper, lead and zinc anodes are described and illustrated. Various types of nickel anodes are listed along with recommended applications and *p*H ranges. One full page of drawings gives instructions on how to order hooks for round, flat and shaped lead anodes. Descriptions and recommended applications are given for several styles of laboratory checked anode bags. Instructions on how to order regular anode hooks are given. Titanium anode baskets are the latest addition to H-VW-M's anode accessory line.

L—902. SPRAY CLEANING—"Wyandotte Products for Spray Cleaning" is the title for the six-page folder F-2889 that covers one-operation cleaning and phosphating, simultaneous cleaning and rustproofing, heavy-duty cleaning without foaming, aluminum cleaning without etching.

Under "Selecting the Right Spray Cleaner for the Job" is a detailed enumeration of the principal factors to be considered in setting up spray cleaning operations.

L—903. FILTERS—Four new bulletins on its line of filtration equipment have just been published by Industrial Filter & Pump Mfg. Co.

Bulletin 112 covers the firm's Type 112 vertical pressure filter. This type features three styles for both wet and dry cake discharge. Bulletin 114 describes the "Hydra-Shoe" Type 114 filter, an exclusive design that employs back-flow pressure to facilitate its operation.

Bulletin 122 tells of the Type 122 horizontal pressure filter, a series with interchangeable and individually removable filter leaves. Bulletin 123 describes the Type 123 tubular filter, applicable for usage with liquids in the chemical, food and plating process industries.

L—904. CLEANING-PHOSPHATING—A new, informative, four-page booklet outlining the merits of Oakite CrysCoat 187, an iron phosphating material especially designed for simultaneous cleaning and phosphating by tank application, has just been released by Oakite Products, Inc. Its chemical stability, corrosion control, long solution life and dual action of cleaning and phosphating are among the particular advantages cited for CrysCoat 187.

A new, 8-page, illustrated booklet detailing the latest methods of cleaning steel before electroplating also has just been released by Oakite. Entitled "The 3 Essential Steps in Cleaning Steel Before Electroplating," the booklet is actually a "basic handbook." In addition, it features detailed outlines of specific procedures (names materials, concentrations, temperatures and treatment times) and colorful diagrams illustrating the mechanics of both direct current and reverse current electrocleaning.

L—905. RUSTPROOFING OIL—Entek RPO-12, a thin, organic liquid which is said to give improved protection to steel

20,000 drumfuls say you take no chances...

Cutting corners on rack coating quality subjects a bath to contamination trouble at worst...or incurs short rack coating life at best.

It doesn't pay. Thousands of gallons of plating solution are a costly investment. Operating problems from contamination take their toll in lost production. And saving a few cents per rack at the start turns out to be no saving at all if racks fail prematurely.

INDICATE A 988.

surfaces, has been developed and described in literature furnished by Enthone, Inc. It is designed to provide temporary rust-proofing to parts in process between manufacturing operations, to parts in storage, or to parts during shipment.

Plain carbon steel dipped in full strength Entek RPO-12 reportedly will withstand 40 hours exposure to salt spray (using Federal Test Standard No. 151), or more than 45 days exposure to tropical humidity tests (100 per cent humidity at 100F). It is for use after blackening, dry or wet grinding, machining, sand blasting, tumbling of iron and steel parts, or to protect valuable steel tools and dies when not in use.

Entek RPO-12 may be applied by dipping, spraying, brushing or tumbling. For maximum rust protection of up to one year and optimum water displacing ability, the manufacturer advises that it be used at full strength. For more limited rust protection, it may be diluted with safety solvent at a ratio of one part solvent to one part Entek RPO-12 by volume.

L—905. CONVERSION COATING—A new chromate conversion coating for zinc or cadmium which eliminates the handling of liquid acid in chromating is fully described in Technical Data Sheet No. 129, a three-page usage and instruction sheet prepared by MacDermid Incorporated.

Called MACro Brite L-10B, the product produces either a leach-type bright finish or an iridescent bronze finish. Control and maintenance is claimed to be simplified, since the product is in dry powder form easily dissolved in water. It can be used on barrel or rack-plated zinc or cadmium work and can be easily adjusted to automatic plating machines with varying immersion periods.

L—907. STRESS MEASUREMENT—A brochure has been made available by the Joseph B. Kushner Electroplating School describing the Stresometer, a practical instrument for determining residual stress in chemically and electrochemically deposited metals. Invented by Dr. Kushner, this instrument which was first marketed in 1958, now has new engineering improvements for measuring stress. The brochure describes the Stresometer and its operation. Typical results obtained with three types of plating solutions are illustrated.

L—908. CHEMICAL NICKEL PLATING—The Kanigen chemically deposited nickel alloy coating process is described in a 12-page brochure just published by General American Transportation Corp. It contains data on commodities and test conditions under which chemical nickel plating is considered suitable, methods used, and how to obtain the coating.

L—909. RIGID POLYVINYL CHLORIDE—A 24-page catalog RV-61 covering its Rigid PVC products has been made available by Kaykor Products Corp. It furnishes basic material data, fabrication and design information, applications in the electroplating industry—such as exhaust hoods for tank fumes.

L—910. PLATING, POLISHING AND PAINTING—A new, fully illustrated four-page brochure describing nineteen different basic types of electroplating, polishing and spray painting equipment available from J. Holland and Sons, Inc. is being offered free.

L—911. RUST CONTROL—A concise, eight-page guide to controlling rust during production operations, has been incorporated into a Rust Control Data File being offered free of charge by Magnus Chemical Co.

The guide details the known and little-known causes of rust, the six factors vital to successful rust control, the many specialized rust prevention products which are available and methods of selecting the proper rust preventive for specific operations and degrees of control.

L—912. ACID-PROOF CEMENTS—"Resistance Charts for Acid-Proof Cements," a new bulletin to guide in selecting the proper acid-proof cement for corrosion proof installations, is available from the Acid-Proof Cement Manufacturers Association, 1015 Chestnut St., Philadelphia 7, Pa.

This bulletin contains a list of more than 75 corrodent solutions and a rating for the various types of acid-proof cements at temperatures of 75 and 140F.

when you have Coating 218X on racks

Twenty thousand drums of outstanding rack coating performance back up every user of Unichrome Coating 218X. Here is the original, heavy duty vinyl plastisol rack coating. What better proof of quality and satisfactory service than those million gallons, covering millions of racks?

The best quality is your greatest economy in the long run. Be sure to have a nearby applicator coat *your* racks with Coating 218X. Ask for names. Or do it yourself if you have baking facilities.

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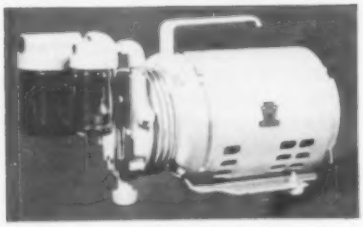
EQUIPMENT AND SUPPLIES



E—901. VACUUM PUMP—A new compact and completely portable vacuum pump has been developed by the Clark-Cooper Division of Frederic B. Stevens, Inc.

The lightweight sliding vane pump is reported to have a maximum vacuum of 27 in. Hg, and will move up to 1.5 cfm of air with entrained liquids. It features a standard 1/6 hp, 115 v 60 cycle motor of the open drip-proof type. A wide variety of special voltages and enclosures are available depending on individual requirements.

The entire assembly is contained in an attractive fine grain grey cast iron housing. It weighs only 25 lb and is delivered ready to use with carrying handle, cord and plug.

E—902. NITRIDING PROCESS—The Tufftride process—which is said to make metals stronger and tougher, a new concept for nitriding—is being introduced in North America by the Kolene Corp. under an exclusive license from Degussa-Durferrit (West Germany), developers of the process.

Applied to any ferrous metal, Tufftriding is claimed to increase corrosion resistance (except for stainless steels), raise resistance to galling, provide better wear properties, increase fatigue strength, reduce cracking and raise rolling fatigue limits. As opposed to conventional nitriding, Tufftriding is accomplished in a low-temperature (1050 F) molten-salt bath. Time at temperature is considerably less so possibility of distortion is minimized.

E—903. ELECTROPLATING POWER UNITS—Warner Electric Company announces three new electroplating power units to cover a full range of plating operations from quantity production to custom-

ized experiments for business, industrial or school shop use.

Rated at 5, 10 and 50 amp capacity, each unit is capable of electroplating copper, cadmium, nickel, chrome, brass, silver and gold by both tank and brush type methods. Units require no special wiring or installation, operate from a standard 110–220 volt, 50–60 cycle, single phase ac current. Complete operating instructions included.

Power units feature Continuous Range Auto Transformer to permit infinite control of current and voltage, plus automatic

MOISTURE-FREE SURFACES in 1/2 THE TIME!

Model 20 New Holland KREIDER Centrifugal Dryer

Air-dries . . . as it Spin-dries! Eliminates scoring and marring . . . speeds up production . . . cuts down on rejects!

SPECIFICATIONS:
1-h.p. motor—220, 440, 550 volts—2 or 3 phase. Spins 75-lb. loads at 825 r.p.m. Quiet V-belt drive. Arc-welded steel plate construction. Weight 490 lbs. Requires minimum floor space. Meets N.E.C. specs. Auxiliary electric or steam heating units available as optional equipment.

Send for illustrated 4-page folder. Write Dept. P-961

NEW HOLLAND MACHINE COMPANY
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A fast inexpensive way to clean your plating racks

SIMPLE, AIR OPERATED TOOL
Adjustable . prevents rack injury

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APPLICATORS OF PLASTISOL
1040 SOUTH MAIN ST. • WATERBURY, CONN.

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protection against overload and short circuits. Full wave rectification assures efficiency at all times. Tested capacity ratings are conservative to provide an additional safety factor and ample power reserve.

E—904. SILICON RECTIFIERS—Allied Research Products, Inc. has introduced a new line of compact silicon rectifiers, featuring small size, lower price, flexibility in arrangement and exclusive protective devices.

Although the cabinet size has been reduced by 45 per cent, the new compact line is said to match standard sized rectifiers in performance. Over-size heat sinks and increased capacity of diodes reduce

danger of overheating. An extra large fan draws air over the heat sinks and transformers and reportedly keeps ambient temperatures well below critical stage.

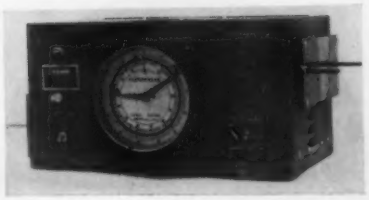
Building block design of the new rectifiers allows use in either a vertical or horizontal position, and permits addition of extra capacity by stacking rectifiers on top of one another or placing them side by side.

E—905. CENTRIFUGAL DRYER—A new centrifugal dryer for the electroplating industry uses a completely new heat circulation design to boost efficiency and cut drying time, according to the manufacturer, The Udylite Corporation. Duct system is specially designed to permit the heater to be mounted in the rear of the dryer. Heat is drawn through the ducts in the cover and over the work at a more efficient rate. A central drive shaft mounted on Timken roller bearings in a reinforced welded base reportedly adds service life to the dryer. Rugged power drive easily handles heaviest production loads. The totally enclosed, fan-cooled, extractor-design ball bearing motor is claimed to have a positive electric brake for quick smooth stops under load. Controls are front-mounted within easy reach of the operator.

E—906. NICKEL PLATING—Satisfactory direct plating of nickel on the new zinc based material called Hydro-T-Metal is said to be possible through the use of the Zialite® plating solution, developed specifically for the nickel plating of zinc diecastings. Items to be plated are cleaned by ordinary methods and then transferred directly into the Zialite® bath without the need for special flashes or dips.

Because of its low solubility in zinc, fine grain structure and throwing power, Zialite® nickel is claimed to provide an excellent interface between the base metal and coatings soluble in the base material.

E—907. PERIODIC REVERSER—Ramm Rectifier Co.'s periodic reverser is said to offer the utility of two pieces of equipment at the price of one. It is a



simply operated, direct current reverser. With the flip of a switch it becomes a dc interrupter.

Ramm also incorporates the 'Ramm Lite' which is not a safety fuse and an indicating light to isolate the area of trouble.

Model RCT operates from 115 v source and is available in ranges from 100 to zero amperes.

Once you use it you'll Order... Again... and Again... and Again!

Every can filled with a full weight of extra high quality 99.75+% Chromic Acid. Prompt delivery made from ample factory and nearby distributor stocks.

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1—10000/5000 Amp., 12/24 V., **H.VW-M,** 40° C. Synch., Exc-in-Head.
1—10000/5000 AMPERE, 6/12 V. 40° C. **CHANDEYSSON** Synch.
1—7500/3750 AMPERE, 9/18 VOLT, **H-VW-M,** Synch. 40° C.
1—6000/3000 AMPERE, 6/12 VOLT, **ELECTRIC PRODUCTS,** Synch.
1—5000/2500 AMPERE, 12/24 VOLT, **CHANDEYSSON,** Synch.
1—5000/2500 AMP., 9/18 V., 40° C., **CHANDEYSSON,** Synch.
1—5000/2500 AMPERE, 6/12 VOLT, 25° C. **CHANDEYSSON,** Synch.
1—4000/2000 Amp., 12/24 V. **CHANDEYSSON** 40° C. Synch.
1—4000/2000 AMPERE, 6/12 VOLT, **H-VW-M,** Synch.
1—3000/1500 AMPERE, 12/24 VOLT, **CHANDEYSSON,** Synch.
1—2000/1000 AMPERE, 6/12 VOLT, **H-VW-M,** Synch.

ANODIZERS

1—1000 AMPERE, 40 VOLT, **CHANDEYSSON,** 25° C. and other sizes in stock for immediate delivery; write for details.
2—400 Amp., 40 Volt **MGC.**
1—500 AMP., 24 VOLT **CHANDEYSSON,** Synch. Exc-in-Head.

RECTIFIERS

1—**H-VW-M** Selenium 5000 Amp., 6 V. S.C.F.C. 440/3/60.
2—**H-VW-M** Selenium 3000 Amp., 6 V. S.C.F.C. 440/3/60.
1—**RICHARDSON-ALLEN** Selenium 2500 Amp., 6 V., Remote.
1—**NEW G. E.** 2000/1000 AMPS., 6/12 V. Remote Control 440/3/60 AC.
5—**UDYLITE** No. UV-12 JD Basic, 1500/750 Amp., 12/24 V., Controls Available.
2—**RAPID**—1500 Amp. Periodic reversers.

MISCELLANEOUS

1—**KREIDER** Centrifugal Drier with Heat.
2—R-100 and R-200 **RONCI** Enamelers.
3—**LASALCO** Ball Burnishers, No. 1, 2 & 4, Lined or Unlined.
1—**HAMMOND** No. VRO-7, 7½ H.P. Variable Speed Buffing Lathes.
10—Buffing Lathes—**HAMMOND, DIVINE, U. S.,** etc., from 3 H.P. to 20 H.P. Single & variable speed.
3—**ACME** Semi-Auto, B/10 Buffing Machines.
2—**AUTOMATIC** Buffing Machines Model 45 Single Spindle.
1—**PRODUCTION** Model A pipe polisher with feed troughs.
3—**PRODUCTION** No. 101 pipe polishers. Individual or in tandem.
1—**HAMMOND** pipe polisher.
1—**STEVEN BADER** Belt Polisher.
1—**ILG** BC-80 Blower Phenolic Coated, V-Belted, 10 H.P. Motor.
1—**AMERICAN** Blower type HS fans. Size 330-10.
8—**DUSKOP** Dust Collector Cabinets. Sizes No. 550, No. 850.
2—Model A **NIEHAUS** fume separators. 1 steel and 1 S. S.
1—**H-VW-M Munning**-Type (Mechanical lift), Full Automatic, Plating Machine 70' long x 4' wide x 36" deep x 10½' overall height.
1—**CROWN** 48 x 36, 2 compartment horizontal tumbling barrel lined.
1—**ACME** L8L Semi-Automatic buffing machine. 8 spindles with 2 7½ HP heads.

M. E. BAKER CO.
Kirkland 7-5460
25 Wheeler St., Cambridge 38, Mass.

E—908. BLACK OXIDE FINISH—The Mitchell-Bradford Chemical Co. announces that they have been granted a U. S. Patent on their new "Activated" Black Magic for producing a black oxide finish on steel (ferrous metals). This new "Activated" Black Magic is the latest development in the line of the firm's blackening processes and it is claimed to be a step forward in black oxide processing. It is a new approach to a black oxide process because of its constant, automatic self-regenerating, decontaminating, catalytic action along with other vitally important and unusual characteristics. It contains new concepts of activators, catalysts, penetrants and rectifiers. This produces advantageous results in operation, processing and final resultant black finish. The new concept of self-rectification for counteracting contaminants and build up of bothersome red oxides also eliminates the necessity of using separate additives. The product reduces processing time, lowers salt consumption because of excellent drain-off and less salts per gallon. It is free-rinsing and produces a denser black and clean finish.

As in previous Black Magic black oxide processes the new "Activated" Black Magic for steel is a single bath with one chemically balanced salt for additions to the blackening solution.

E—909. ULTRASONIC CLEANERS—A complete line of accessories for the new Autosonic self-tuning ultrasonic cleaners is now available from Powertron Ultrasonics Corporation. The accessory line is designed to take full advantage of the 90 per cent efficiency performance offered by the Autosonic cleaners, which tune themselves for constant cleaning performance by means of an exclusive feedback transducer.

Seven basic shapes, all of stainless steel with dual handles accommodate every size of tank in the self-tuning cleaner line. Covers which eliminate undesirable odors and fumes during cleaning are also available.

E—910. SMALL VIBRATOR—Addition of a small "bench" model to its line of vibratory finishing equipment is announced by Lord Chemical Corporation, York, Pa.

The new machine, designated Model 610, has a ¼ cu ft capacity, with a bowl measuring 6 in. wide, 10 in. long and 8 in. deep. Overall dimensions of the machine are 12 in. wide, 34 in. long and 28 in. high. Designed for finishing of small and delicate parts, the machine has a load capacity of approximately 35 lb or parts and media.

E—911. AUTOMATIC FINISHING MACHINE—Hydra-Blast automatic machine announced by Hydra and Power Blast Mfg. Division's Automation Serv-

VITREOSIL heaters are **pure fused silica . . .** ideal for heating acid pickling and electro-plating solutions and other acid baths. VITREOSIL Electric Immersion Heaters can be used with phosphoric acid **at temperatures up to 200°C** and with certain cyanide baths under controlled conditions. Besides immunity to extreme chemical, electrical, and thermal conditions . . . besides offering exceptional characteristics, VITREOSIL heaters feature:

- **Increased heat transfer per unit area**
- **Greater resistance to chemical attack**
- **Molded rubber cap for efficient sealing and simple installation**
- **Ground wire inside the sheath for additional electrical protection**
- **Markings for minimum safe immersion depth**
- **Outer silica sheath easily replaceable**

See our ad in Chemical Engineering, Electronic Engineers Master and Electronic Designers' Catalogues.

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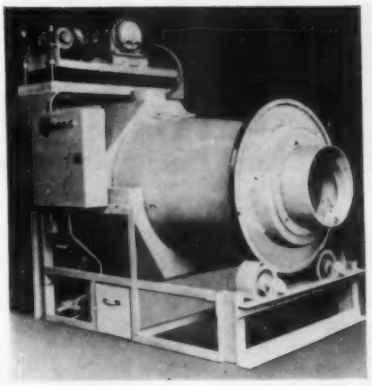
THERMAL AMERICAN FUSED QUARTZ CO., INC.
18-20 Salem St., Dover, New Jersey

ices, Inc. is said to produce a variety of uniform and consistent precision finishes on eye glass frame pieces, jewelry and other decorative articles. Hard-to-reach areas on aircraft, camera, electronic, instrument and missile components may also be cleaned, deburred or descaled, replacing tedious hand operations.

This high production wet-blaster features stainless steel construction, "Electromation" pull-push controls, flash-o-cycle indicating lights, adjustable blast-guns, a complete process incorporating self-unload and oxi-gard stations. The "Jeturbo" system provides reliable, trouble-free performance since pumps and moving parts have been eliminated from the blast-circuit.

E—912. SAWDUST BARREL—Automatic control of tumbling cycles, automatic separation and media retention and automatic discharge of finished parts are features of a 36-inch sawdust barrel announced by Minnesota Mining and Manufacturing Co.

Additional automation is afforded with a storage hopper and power loading equipment. Both are optional. The "Honite" brand automated barrel is designed to minimize hand labor in batch drying and polishing metal parts.



Gas heats the drum. A metal hood retains the heat in the tumbling compartment. Parts are fed in one end and discharged at the other. The media remain in the barrel ready for reuse, or can be discharged automatically.

A magnetic separator is standard equipment. It can be replaced by a vibratory separator, employing interchangeable screens, for drying and polishing nonferrous parts.

E—913. RUST PREVENTIVE—A low-cost, water-compatible, non-flammable rust preventive that can be applied directly to dry surfaces or to surfaces wet with water or with soluble cutting oil emulsions has been introduced by Magnus Chemical Co.

The new product, Magnafilm 230, is claimed to furnish excellent indoor protection, eliminate the fire hazard often associated with solvent-cutback rust preventives, remove corrosive fingerprints and, in addition, provide protection against fingerprint damage during subsequent handling.

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Rhodium electroplate is suggested for these applications: on wave guides and microwave equipment which may be used in marine atmosphere; in printed circuits; in electrical contacts where light contact pressure and low voltages are involved... Rhodium is very hard and corrosion-resistant.

This Rhodium plating solution is easy to use. It operates over a wide range of temperatures and current densities. We will be glad to plate samples without charge.

Backed by 60 Years of Specialization

Consult our staff about plating problems.

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PERSONALS

L. C. SORENSEN was elected chairman of the board, **WILLIAM SORENSEN** elected president and **LOUIS McDONALD** elected executive vice president of Kelite Corporation at the regular organization meeting.

L. C. Sorensen is the founder of Kelite and served as its president from 1937 to 1961. He will continue as chief executive officer.

William Sorensen is a graduate of the University of California, where he majored in business administration. He joined the company in 1948 and has served in recent years as executive vice president and marketing director.

Mr. McDonald is a chemical engineering graduate of the University of Virginia and is the holder of many patents in the chemical and detergent field. He joined Kelite in 1951 as laboratory director and subsequently became vice president-technical director. He will continue as technical director.

L. C. Sorensen

W. Sorsensen

L. McDonald

R. B. Cassidy

ROBERT B. CASSIDY has been appointed a sales engineer by Allied Research Products, Inc., Baltimore, Maryland for the southern territory.

From his office, located on Route No. 8, Greenville, Tennessee, Mr. Cassidy now serves the states of Tennessee, Alabama, Georgia, Florida and Mississippi.

In joining Allied, Mr. Cassidy brings with him an extensive background, having spent three years as plating superintendent with the Metals Engineering Company in Greenville, and a number of years in plating plants in Michigan. He has been a member of the American Electroplaters' Society for 12 years.

♦

DR. CHARLES E. McGINN has been appointed assistant director of research for Solvay Process Division, Allied Chemical Corporation.

Dr. McGinn joined Allied Chemical's National Aniline Division in 1941 as a chemist at the Buffalo research and development laboratory. Prior to being named manager of research, chemicals, in 1959 he was a group leader of National Aniline's polymer chemicals group. In his new position he will be located at Solvay's Research Laboratory, Syracuse, N. Y.

A graduate of the University of Virginia, Dr. McGinn holds a BS degree in chemistry and a PhD degree in organic chemistry.

JEROME L. ROSS has been promoted from assistant manager to general manager of The Meaker Company, subsidiary of Sel-Rex Corporation. Sales engineer with Sel-Rex since 1949, Mr. Ross was in charge of plating equipment and supplies sales for two years, and had also been manager of the company's Equipment Division, responsible for engineering and pricing.

A chemical engineering graduate of Columbia University, he had held technical, administrative and executive positions in the metal finishing industry for nearly 20 years prior to joining Sel-Rex.

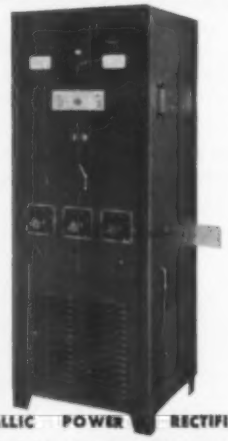
According to the announcement, in his new position, Mr. Ross will have full responsibility for engineering, manufacturing and sales for Meaker products, and will continue to make his headquarters at the Meaker factory and general offices at 1629-41 South 55th Avenue, Chicago, Illinois.

♦

JAMES McWHIRTER, general manager of Industrial Chemicals Division, Pennsalt Chemicals Corporation, has been elected a vice president of the company.

Since becoming associated with the firm in 1945, he has successively served as plant superintendent at Pennsalt locations in Natrona, Pa., Calvert City, Ky., and Wyandotte, Michigan. In 1952, when Sharples Chemicals Inc. merged with

Clinton



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"pH PAPERS"

Accurate pH Values in a few seconds right at the tank.

Indicator AND control-colors on SAME strip. Control-colors in steps of 0.2 pH and 0.3 pH.

Plating ranges

(200 strips of a range per box)

Acid:	Alkaline:
6.0–7.4 pH	6.6– 8.0 pH
*4.8–6.2 pH	7.3– 8.7 pH
*3.6–5.0 pH	8.6–10.0 pH
*2.4–3.9 pH	10.1–11.3 pH
1.0–2.8 pH	10.5–13.0 pH
0.4–1.4 pH	11.0–13.1 pH

*Electrometric Values in Nickel Solutions.

Each range is boxed separately.

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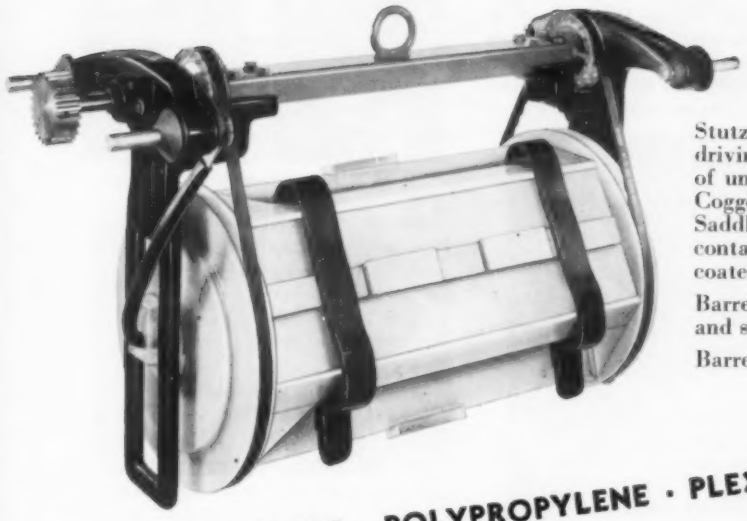
INDICATE A 947.

INDICATE A 948. ➤

The NEW STUTZ Plating Barrels

ORIGINATOR OF

1. **LOW HEADROOM DESIGN**
2. **COMPLETELY COATED HANGER ARMS**
3. **QUICK CHANGE BELTS**



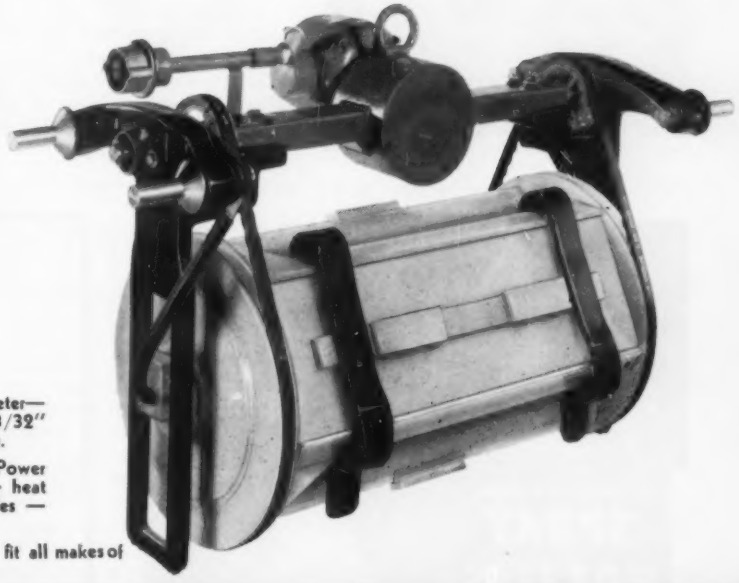
Stutz Complete Cycle Assembly for operation in tanks with driving mechanism located externally. Lifting and lowering of unit reduced to a minimum. Barrel is totally submerged. Cogged drive belts can be changed in seconds without tools. Saddle horns are 1" or 1¼" diameter. Cathode dangler type contacts are standard, with others available. Hanger arms coated with Vulcanized Hard Rubber or Rigid Plastisol.

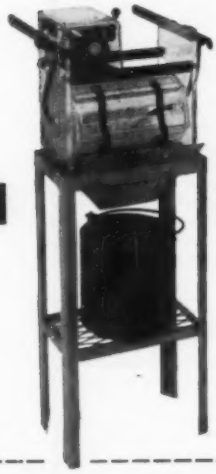
Barrels can be supplied in special sizes, also with partitions and special contacts as required.

Barrel assembly units are made to fit all makes of tanks.

. . . NEW MATERIALS · POLYPROPYLENE · PLEXIGLAS · TEMPRON · MELAMINE . . .

Barrel rotation in this design is provided by motor drive mounted directly in superstructure bridge member. Fast handling as total weight and overall height have been greatly reduced. Barrel transported from one operation to the next under continuous rotation. Solution dragout is reduced to a minimum. Rinsing time following alkali cleaning, acid pickling, etc., is greatly reduced. Overall dimensions of the tank are lessened by the elimination of motor drive platform. Electric service is 440, 220, or 115 volt with grounded cable and Hubbell-Twist Lock heavy duty safety connector.





Sizes 12" to 18" inside diameter—24" to 42" long—perforations 3/32" standard. All other sizes available.

Tanks in single and multiple—Power equipment — dryers — filters — heat exchangers — chemicals — anodes — ventilation, etc.

Barrel assembly units are made to fit all makes of tanks.

STUTZ *Portable Plating Barrels*

The Stutz Portable Barrel is made in 3 standard sizes with cylinders having inside dimensions of 6"x12", 8"x18" and 10"x20" I.D. Smaller upon application. Standard openings are 3/32". Smaller or larger openings can be furnished as required.

- Baskets in perforated metals or wire mesh.
- Load/Unload Stand for convenient and fast handling of work load.

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The STUTZ Company

4420 West Carroll Ave. Chicago 24, Ill.

COMPLETE METAL FINISHING EQUIPMENT AND SUPPLIES

Pennsalt, he was appointed manager of manufacturing for the newly-formed Industrial Chemicals Division-East. He assumed his present post as general manager of Industrial Chemicals Division-East in 1960.

♦

LOUIS H. GIER has been appointed controller of Industrial Filter & Pump Mfg. Co., Cicero, Illinois. He is a graduate cum laude of the DePaul University College of Commerce, and is presently secretary of the Cicero Manufacturers Association.

Mr. Gier is a member of the Illinois Society of Certified Public Accountants and the Illinois Manufacturers Costs Association.

L. H. Gier

Dr. J. B. Kushner

JOSEPH B. KUSHNER, Professor of Engineering at Evansville College and author and conductor of a correspondence course in electroplating, Evansville, Indiana, has been awarded a National Science Foundation grant to conduct research on electrodeposition.

The sum of $8300 was given to Evansville College to enable Dr. Kushner to carry on research on "The Theory of Stress in Electrodeposits" in the metallurgy laboratory of the college. The project will continue previous work done by Dr. Kushner in the field of stressed electrodeposits. The grant is believed to be the first National Science Foundation grant awarded for basic research in electroplating.

♦

ROLLIN M. RUSSELL has been elected president of Acoustica Associates, Inc., of Los Angeles.

Mr. Russell joined Acoustica early this year as executive vice president. Previously, he had served as executive vice president of Electronic Specialty Co., and as vice president and group executive for Hughes Aircraft Co. He has also held executive posts with Continental Aviation and Engineering Corporation, and Bendix Pacific Division of Bendix Corporation.

A graduate of the University of Wisconsin, Russell also took graduate training at Wisconsin and Northwestern University. He was associated with Johns Hopkins University's applied physics laboratory and the Columbia University underwater sound laboratory.

R. M. Russell

J. H. Shockcor

JOE H. SHOCKCOR has joined the staff of Lancy Laboratories, Inc., Zelienople, Pa., as manager of the Philadelphia office. Lancy Laboratories is a consulting engineering firm, active in the metal finishing industry and metallurgical waste treatment field.

Previously Mr. Shockcor had been a district sales engineer with Enthone, Inc. for nine years, following a two-year period in their laboratory working in research and in technical service. He is a graduate of Lehigh University and holds a BS degree in Chemical Engineering.

He has been active in the Lancaster Branch of the American Electroplaters' Society, having held several offices and served on various committees. He presently is chairman of the Credentials Committee of the Supreme Society of the American Electroplaters' Society.

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in complete choice of spray patterns and capacities
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CONTROLLED-FLOW*
SPRAY NOZZLES
*exact control of pattern, impact, volume and distribution for any liquid at any pressure.
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for better washing coating and rinsing
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TRUE BRITE Nickel Brightener
the original high performance barrel nickel brightener. Still the standard.

BRASS MAINTENANCE Solutions
the easy way to control of color and performance of brass plating.

OXYPHEN pH Papers
Over 30 ranges to suit all possible solutions and conditions.

SODIUM and POTASSIUM Copper Cyanides
Highest quality soluble salts from our own production for all solutions.

Bulletins available on all products

TRUE BRITE CHEMICAL PRODUCTS CO.

96 Falls Ave. Oakville, Conn.

RALPH R. GRANQUIST, Chicago district manager for Hanson-Van Winkle-Munning Company, has retired after serving 38 years with the company. Mr. Granquist joined the company in 1923 beginning as a salesman in the Chicago office. During the late forties, he was one of the few company men to top the $1,000,000-a-year sales mark. In 1952, he was promoted to district manager and was responsible for H-VW-M sales in the mid-west area until his retirement.

R. R. Granquist

J. Girard

JACK GIRARD has been promoted to the position of general manager of the electroplating and coating division of General Magnaplate Corporation, Belleville, New Jersey.

♦

AES LAPEL BUTTONS

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For cleaning these sterling silver buttons, here is one expert member's reported method, "Place hot water in which a little washing soda has been dissolved into an aluminum pan or any container with a small piece of aluminum at bottom (concentration: one tablespoonful of soda to one quart of water). Immerse the button so as to touch aluminum, and allow to soak until tarnish disappears. Operation will clean but will not injure the silver."

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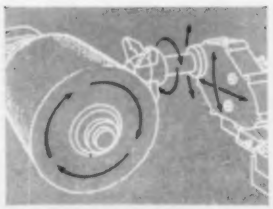

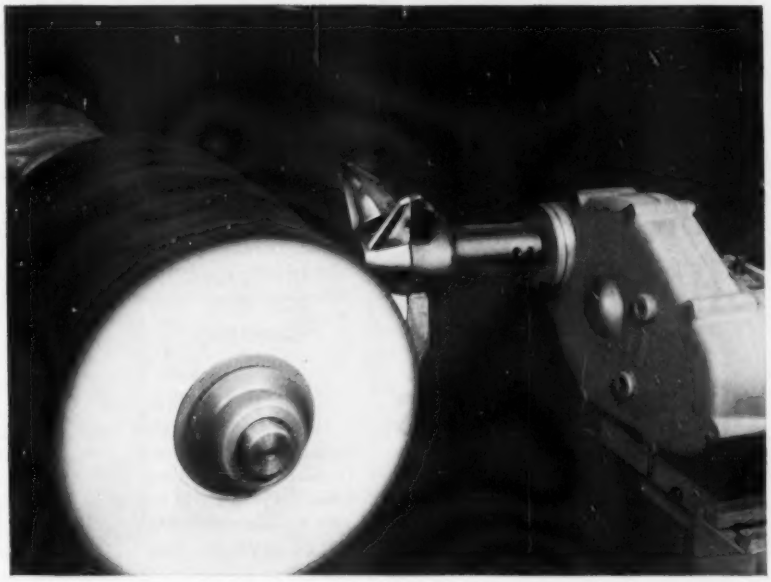

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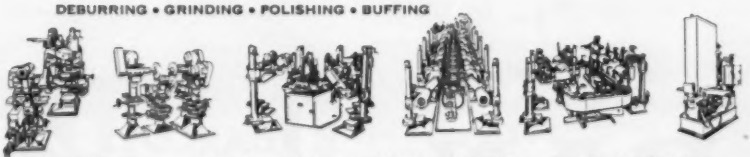

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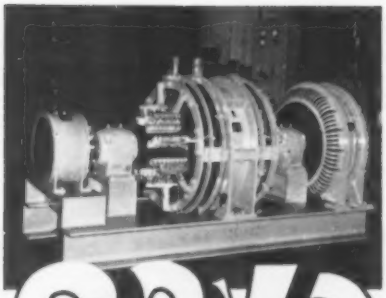

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BERNHARD A. NORDBLOM

Bernhard A. Nordblom, a member of the AES Milwaukee Branch and later of the Mississippi Valley Branch, for a total of more than 43 years, died July 15, 1961 at Davenport, Iowa.

Mr. Nordblom came from Germany to this country at the age of eight. He was 79 at the time of his death. Most of his adult life was spent in the electroplating industry.

He established the Iowa Silver Plating Works in Davenport in 1911. The company has the distinction of being the largest business of its kind west of Chicago. He joined the Milwaukee Branch of the American Electroplaters' Society in 1918.

Mr. Nordblom is survived by his wife and his son, Bernhard J. Nordblom, with whom he was a partner in the silver plating works.

♦

DR. PAUL H. MARGULIES

Dr. Paul H. Margulies, manager of the metals application section of the Chemical Research and Development Center of FMC Corporation in Princeton, N. J., died July 5. He was 60 years old.

Born in Vienna, Austria, Dr. Margulies studied at the University of Vienna and received his PhD degree there in 1925. He joined FMC's Becco Chemical Division in 1939. In 1958 he transferred to FMC's Research and Development Center as head of the metals application section.

Dr. Margulies held 13 patents dealing with active oxygen chemicals and was the author of seven publications in his field. His development of printed circuit etching with persulfate continues to gain industry acceptance. He was a past president of the Etched Circuit Society and a member of the American Electroplaters' Society, American Chemical Society, the Electrochemical Society, and the American Institute of Chemists.

♦

EDWARD L. PEZOLT

Edward L. Pezolt, vice president of the Bradley & Vrooman Company, died July 21 at Passavant Memorial Hospital, Chicago.

A graduate of Northwestern University, Mr. Pezolt was associated with the company for nearly 50 years and was widely known throughout the paint industries and the metal trade.

♦

HENRY W. LONG SR.

Henry W. Long Sr., founder and president of the Aetna Electroplating Co., Philadelphia, died at his home, 2414 Old Welsh Road, Willow Grove, Pa., Tuesday, July 18. He was 84.

Mr. Long was a long time member of AES Philadelphia Branch, joining on June 1, 1928. Surviving are his wife, two sons, two daughters, 14 grandchildren and 42 great-grandchildren, among which are Philadelphia Branch members: son George M. Long and grandson Robert L. Farren.

♦

WILLIAM MAGUIRE

William Maguire, president of the AES Newark Branch in 1941 and 1942, died early in July. He was employed by Western Electric Company and was instrumental in obtaining many members for the Branch.

♦

E. V. COLLINS

E. V. Collins, Newark Branch member in India where as part of the U. S. foreign aid program he instructed in electroplating and metal finishing, died recently. He was, some years ago, an active member of the Waterbury Branch and in more recent years before going to India a faithful attendant at Newark Branch meetings.

♦

PETER TRAVISANO

Peter Travisano, a recent loss to the plating industry through death, was a long-time member of Newark Branch. As owner of the Acme Plating Works of Newark, he consistently supported the Branch activities.

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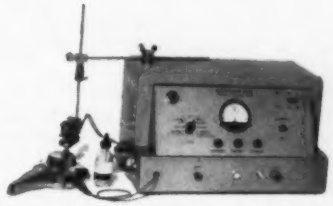

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BRANCH NEWS

Total AES Branches U. S., Canada, Australia, September 1, 1961—61.

BRIDGEPORT

Wesley Installs New Officers

The regularly scheduled business meeting and educational session of the Bridgeport Branch was held in the Winter Quarters of the Hotel Barnum on Friday, May 12, 1961. Forty-seven members and guests were present. President **Hyatt** called the meeting to order at 8:05 p.m. **Dr. W. Andrew Wesley,** National President, was an honored guest. A few moments of silence were observed in respect to **Warren Jones** who died on April 27, 1961.

One application for membership was received and a member was accepted and presented with a membership certificate and pin.

William Hyatt made a preliminary financial report of the New England Regional Meeting; 889 tickets were sold. The hotel had been guaranteed 830.

John Morris asked for and received permission to postpone his Christmas Dinner-Dance report until after the board of managers had reported on the securing of a different site for regular monthly meetings. Upon its completion, Mr. Morris advised us that the Stratfield Hotel ballroom had been secured for December 16, 1961. Accommodations are more spacious. Final details will be made as soon as possible.

Al Ferguson reported on the board of managers' investigation of possible meeting rooms. Many facilities on Connecticut Turnpike had been checked. Moving to the Stratfield Hotel was recommended and accepted.

Dr. Wesley was introduced. He proceeded to charge each respective elected officer with his responsibilities and he installed the following officers of the Branch for the fiscal year 1961–62: President, **William Lindsay Jr.;** first vice president, **Emil Bergen;** second vice president, **Edmond Owen;** secretary-treasurer, **Bob Parker;** Branch educational chairman, John Morris; sergeant-at-arms, **Harry Zingo.**

Immediately after taking office, President Lindsay presented Past President Hyatt with his Past President's Pin. Mr. Hyatt was also given the "Ehreucrona Gavel" in recognition of his fine performance.

Mr. Lindsay appointed the following to committees: sick and welfare, **L. Georgette, Herman Braun;** projectors, **J. Carnicky, P. Bailin;** parliamentarian, **R. Barrett.**

A discussion followed concerning the candidacy of **Ray O'Connor** for Honorary Membership in the National Society.

Phil Bailin suggested that the Delegates vote for raising the dues rather than eliminate the Proceedings.

The Secretary was requested to contact the National Society regarding a suitable uniform identification emblem which could be distributed at a nominal cost to present and incoming members.

The door prize was won by **Vergilio Consalvo.**

At 10:05 p.m., the meeting was adjourned for refreshments. The late hour precluded our having the scheduled forum on electroplating problems. We were entertained by the projection of slides of many of our social events by Richard Barrett; also of his visit to Mexico.

BUFFALO

AES Executive Board to Attend September Meeting

The Buffalo Branch will hold its first meeting of the 1961–1962 season, Friday, September 15, 1961, at the Red Lobster Restaurant, Buffalo, New York.

The Executive Board of the American Electroplaters' Society will be present at this meeting.

Al Korbelak, vice president of marketing and new product development of Sel-Rex Corp., will be the speaker of the evening. Mr. Korbelak has chosen for his topic "Precious Metal Plating and Solderability."

Plans for the new season and reports on the National Convention held in Boston, Mass., will be covered in the business session and will be of utmost importance to all Buffalo Branch members.

The October meeting will be held in Jamestown, New York on Friday, October 13, 1961. The speaker and place of meeting will be announced later.

Robert C. Eich
Secretary

CENTRAL IOWA

Weisberg Speaks on Electroplating History; Officers Announced

On May 18, 1961 the new Central Iowa Branch of the American Electroplaters' Society met at the Hotel Roosevelt, Cedar Rapids, Iowa. After dinner and refreshments, the business meeting was conducted at which time the Temporary Charter was announced and the Bylaws were read and approved.

The officers acting under the Temporary Charter will be as follows: Chairman, **Vern Nuss;** vice chairman, **Harold Simon;** secretary-treasurer, **James Elliott;** librarian, **Tom Negro;** committee: **C. L. Kennedy, Art Hiertz, Fouts Dooley, Harry H. Thomas.**

Al Weisberg of Technic, Inc. was the guest speaker presenting the "History of Electroplating."

Thirty members and guests were present. Summer vacation was called and the next meeting will be September 21, 1961 at the Hotel Roosevelt.

Harry H. Thomas

DALLAS-FORT WORTH

Annual Meeting Set For Sept. 14

The Dallas-Fort Worth Branch annual meeting will be held Thursday, September 14, 1961. This annual affair includes installation of new officers, and a dinner-dance. The Statler Hilton in Dallas has been chosen as the site, with the sumptuous ballroom as the entertainment headquarters.

Our new National Third Vice President, **Edward E. Oberland,** will be guest of honor. Several committee meetings and technical sessions have been planned for the afternoon.

The new officers to be installed by Mr. Oberland are: President, **R. F. Howard;** first vice president, **D. L. Allie;** second vice president, **R. F. Walton;** secretary, **T. E. Betz;** treasurer, **M. A. Davison;** program chairman, **D. Cox;** recording secretary, **E. W. Turns;** board of managers, **M. E. Browning, W. L. Aves Jr., E. R. Rinehart, F. E. Lane.**

Myron E. Browning

DETROIT

Branch Stag Day Enjoyed by 800

Brief thunder showers on July 22, at Glen Oaks Country Club, Farmington, Michigan, did not dampen the festive mood of over 800 members and guests attending the annual Detroit Branch Stag Day.

AES National President **Chester G. Borlet** and First Vice President **Manuel Ben** were present, as well as many friends from neighboring Branches.

There was also a fine showing of Past Presidents, including **Ralph D. Wysong, Herberth E. Head, Cleve Nixon** and **Walter Pinner.**

General Chairman **Louis J. Camill,** with the fine cooperation of the Stag Day

BRANCH SECRETARIES

Branch News is required of all Secretaries monthly by AES Bylaws. First of the month is Branch News deadline for next PLATING issue. Any items on hand on that date will be carried in that edition. Later arrivals will appear in the issue immediately following. In reporting talks given by speakers before the Branch, please give titles of the talks, the speakers' full identification and any other pertinent information of interest to other Branches and PLATING's broad readership.

Committee, had a full, well-organized day planned. There was plenty of activity and entertainment for everyone's tastes and moods. The outstanding door prizes included a portable television set, camera, typewriter and golf clubs.

William Devan
Public Relations Chairman

LOS ANGELES
Joint Meeting With San Diego; Weiner Is Speaker

The Los Angeles Branch of the American Electroplaters' Society held its final meeting of the season on Wednesday evening, June 14, at the Roger Young Auditorium. President **Emmett Babcock** presided. Guests were introduced by Sergeant-at-Arms **Bob Jones.**

It was a joint meeting with the San Diego Branch. Mr. Babcock introduced the president of the visiting Branch, **Harry Steinke,** who spoke briefly on the San Diego Branch and introduced the officers and members in attendance.

Educational Chairman **Gene Bosl** introduced the speaker for the evening, **Gene Weiner.** Mr. Weiner, vice president of Chemtron Research and Development Corp., presented a very informative and educational talk on "Three Dimensional Printed Wiring, Multi-Layer Circuits and Ternary Alloy Plating."

Burton G. Adams
Publicity Chairman

PHOENIX
Awards to Stimulate Membership and Attendance

Committees for the coming year were appointed and plans for the coming year and the future were discussed at the executive committee meeting on June 29.

President **Jim Weaver** will determine progress of Western Branches in forming a Western Regional Group.

Mr. Weaver, with **Bill Bath,** is to contact Arizona Council of Engineering Scientific Association in an attempt to gain membership of our Society into that organization. Jim Weaver and Bill Bath will invite the AES Interim Meeting to Phoenix.

First Vice President **John Mularkey,** chairman of membership and entertainment committee, stated that each member of the executive committee is automatically a member, including the board of managers. A cash award of $10.00 will be given to the member who brings in the most new members for the year (1961–62).

A swimming party was discussed. Place, La Fonda Fiesta, on August 26. The Branch will furnish beer, soft drinks and door prizes. Members must bring their own steak or other food. Facilities will be available for broiling steak and other cooking. Admission $1.00 per person.

The meeting place next year is to be at Arizona Ranch House Inn, 5614 North Central, at 7:00 p.m.

At each of our regular meetings a name will be drawn and if the person is present, a cash award of $5.00 will be presented to him. If he is not present, the $5.00 will be put in a kitty and added to the drawing for the next month. The purpose is to stimulate membership.

Members of the Christmas Party Committee are **Floyd Huhn, Sam Lewin, John Birmingham, Bob Hays** and **Frank Saurette.**

If Dr. Faust accepts speaking engagement for joint meeting of American Society for Metals and AES in February, **Paul Wible** will explore possibility of inviting American Chemical Society to the meeting.

Education Chairman Bill Bath reported on the Spring Symposium. **Gordon Perrine** and **Seymour Thomas** will be asked to serve on the committee. He is to contact the National Society to obtain one of the National Officers as a speaker for one meeting. One meeting a year is to be a plant tour.

Neva Johnson, chairman of literature and training, to contact **George Carlton** for information and assistance in setting up a course in electroplating in conjunction with the American Society for Metals.

Paul M. Wible
Acting Secretary
Ron Dezember
Secretary

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PORTLAND
Nunn Talks on Barrel Finishing

The monthly meeting was held on June 15 at the Olde Towne Crier Restaurant. Cocktails were served at 6:15 p.m. and dinner began promptly at 7:00. The business meeting was opened at 9 o'clock by President **Everett Cook,** with the members introducing themselves and their guests. The Branch then presented Branch Past President **Vernon Schoenbeck** with the Past President's pin and gave him a vote of thanks for a job "well done."

Discussion was then opened on the subject of the proposed annual dues increase to be submitted to the Delegates at the Boston Convention this month. Everett Cook read the statement from the Lancaster Branch urging members to reject the dues increase. The budget figures from National Headquarters were read and discussed in regard to the question of the dues. **Dr. L. Underdahl** stated that due to the amount of research by technical men that is available in PLATING MAGAZINE, he was in favor of the increase, and then made the motion to accept the increase. The motion was seconded, and the vote was carried by the majority. The Delegate was then instructed to present the Branch's feeling to the National body in Boston.

Ken Smith introduced our guest speaker for the evening, **William P. Nunn,** Honite engineer of Minnesota Mining and Manufacturing Co. His topic was "Barrel and Vibratory Finishing." Mr. Nunn described the history of barrel finishing, the types of media used, and the development of vibratory finishing. He explained the different types of barrels used and showed samples of work finished in the vibratory barrels. Interest was great in the improvement on soft metal finishes and on fragile parts in the electronic fields. Time was set aside for a "question-and-answer" period.

Everett Cook announced that this would be our last meeting until September. First Vice President **Bob Finzer** stated that the announcement of the next Electroplater's School would be deferred until the fall meetings. Meeting adjourned at 10:30 p.m.

A. Everett Cook
President

PLATING MAGAZINE invites AES Branches to furnish news for publication in PLATING concerning electroplating courses sponsored.

ROCKFORD
Stream Pollution Movie Shown; Delegates Instructed

The Rockford Branch held a regular business meeting at the Faust Hotel on June 12 for the purpose of instructing its delegates to the Boston Convention. Long and sometimes stormy discussions were presented on the various matters to be considered by the Supreme Society. Over 30 members took part in these discussions and when the evening was over, the Delegates had full instructions from the membership.

President **Harold Ellis** reluctantly announced the resignation of our Librarian, **Bob Campbell,** who had been re-elected to serve a second term. Other commitments, both civic and personal make it impossible for Bob to continue in this office. A standing ovation showed the Branch's appreciation for a job well done.

Tom McCullough of National Lock Co. was appointed to serve out the unexpired term and has presented various fine and interesting ideas for our next year's program.

A movie on Stream Pollution was shown through the courtesy of the Rockford Sanitary District.

Alexander Alexander
Publicity Chairman

FUTURE MEETINGS

Education is the business of AES. For National, Regional and Branch educational and other AES meetings ahead, see PLATING's section titled FUTURE MEETINGS herein.

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BROOKLYN, N. Y.—Ft. Greene Evening High School
Louis Serota, Instructor
18-wk. course—Fee: None

CHICAGO, ILL.—Illinois Institute of Technology
J. M. Andrus, Instructor
18-wk. course—Fee: $80

CLEVELAND, OHIO—Max S. Hayes Trade School
H. Pochapsky Instructor
15-wk. course—Fee: $11

INDIANAPOLIS, IND.—Purdue University Extension
Dr. A. M. Max, Instructor
16-wk. course—Fee: $45

MONTREAL, QUE.—Polytechnique Institute
Dr. Andre Hone, Instructor
3-year course—Fee: $50

NEWARK, N. J.—Plants and Laboratories in Area
F. J. LaManna, Instructor
Climax-Grayway Co., 560 Winters Ave., Paramus, N. J.
14-wk. course—Fee: $25

NEW HAVEN, CONN.—New Haven College
L. J. Durney, Instructor
4–15 wk. Semesters—Fee: $50 per semester
Sept. 1961–Jan. 1962—Electroplating Practice
Feb.–June 1962—Electroplating Fundamentals
Students may enter at any point.

PHILADELPHIA, PA.—Temple University Technical Institute
Dr. S. Heiman, Instructor
4 Semesters, each 16 wks.—Fee: $37 per Sem.

PORTLAND, OREGON—Portland State College
Dr. J. R. Mickelsen, Instructor
10-wk. course —Fee: $10

PROVIDENCE, R. I.—Central Senior High School
Omer Jette, J. Fogarty, J.Castriotta Instructors
2-year course—Fee: None

ST. LOUIS, MO.—Hadley Technical H. S.
Dr. Otto C. Klein, Instructor
16-wk. course—Fee: $10

SAN ANTONIO, TEX.—Trinity University
W. P. Wisdom, Instructor
18-wk. course—Fee: $10

SAN FRANCISCO, CAL.—Cubberly H. S., Palo Alto
William Ferry, Instructor
24-wk. course—Fee: $3 per 12wk semester

SOUTH BEND, IND.
Dr. H. J. Wiesner, Instructor

SPRINGFIELD, MASS.—Chicopee Vocational H. S.
R. J. Girard and E. F. Koetsch Jr., Instructors
Two 12-wk. courses—Fee: None

TORONTO, ONT.—Central Technical High School
R. H. Clark, Instructor
22-wk. course—Fee: $15—non-res.
$ 5—city res.

VANCOUVER, B. C.—Vancouver Technical School
Walter Kellerman, Instructor
6-mo. course—Fee: $15

EVANSVILLE, IND.—Joseph B. Kushner Electroplating School
Joseph B. Kushner, Instructor, 621 S. Norman Ave.
4 mos. to 1 yr. correspondence courses—Fee: $150

SANTE FE SPRINGS, CAL.—Weiner Electroplating School
Milton Weiner, Instructor, 12631 Imperial Highway
3 courses, each 12 weeks—Fee: $40
Practical Electroplating & Metal Finishing, starts Sept. 18, 1961
Theoretical Chemistry & Electrochemistry, starts Jan. 8, 1962
Theoretical & Practical cost & calculations, starts Apr. 2, 1962

The above listings were correct so far as could be ascertained at press time. Prospective students are urged to verify courses and fees prior to making definite plans.

PLATING MAGAZINE

OPPORTUNITY TO AUTHORS

Member or non-member authors of technical and scientific papers on electroplating, metal finishing and allied arts are cordially invited to submit manuscripts of original, unpublished papers to the Editor of PLATING MAGAZINE for review and publishing consideration.

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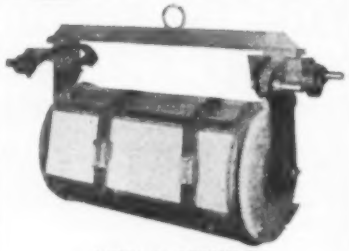

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INDUSTRY NEWS

(Continued from page 1032)

MACDERMID AWARDS SERVICE PINS

Service Award Pins for service from 25 years to 5 years were presented to employes of MacDermid Incorporated, Waterbury, Connecticut, by President Harold Leever, at the company's annual outing following a sales meeting in July.

Fifteen-year pins: Gerry Sullivan, Ed Stack and Doug Lunan.

Ten-year pins: Virginia Leever, Gordon Jones, Al Butterer, Terry Caldwell, Doctor Taylor, Irene Granoth and Dick Nyquist.

Five-year pins: Harold Lazaar, Ethel Corrigan and Jerry Post.

Service pins were also presented to wives of MacDermid men who received awards.

♦

INTERNATIONAL INDUSTRIAL FINISHES EXHIBITION SUCCESS

More than 15,000 visitors from Britain and most overseas countries went to the successful First International Industrial Finishes Exhibition May 8–11 which was held at Earls Court, London.

Exhibits covered every aspect of finishing and while it is not possible to state the total amount of business done, "sold" notices on exhibits became more and more familiar as the exhibition progressed. Well over half the exhibitors have already rebooked for the next exhibition, many wanting increased stand areas.

The Exhibition was opened by The Rt. Hon. the Viscount Davidson, PC, GCVO, CH, CB, president of The Engineering Industries Association, supported by A. A. B. Harvey, BSc, president of the Institute of Metal Finishing.

Held at the same time as the exhibition, the Industrial Finishes Convention attracted nearly 400 delegates. There was an excellent attendance at all papers and the lively discussions that followed showed conclusively the need for this type of meeting where practical problems could be discussed without commercial considerations entering into the matter.

Such was the success of the first exhibition that preparations for the second to be held May 20–24, 1963 are well advanced, for which the organizers have been able to secure a much larger area of Earls Court. Early application for stand space should be made to the Organizer, Exhibition Division, Scientific Surveys Ltd., 97 Old Brompton Road, London, S. W. 7.

CLASSIFIED ADVERTISEMENTS

Only "Help Wanted" and "Situations Wanted" will be accepted. Rates: $.20 per word, minimum $5.00. AES Branch Members and Members-at-Large only, in good standing, are entitled (for personal use only) to a total of three free advertisements in any twelve-month period as of first insertion. Last day for inserting advertisements is the 10th of month preceding date of publication. When answering advertisements please address as follows: Box number, PLATING, 445 Broad Street, Newark 2, N. J.

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FINISHING SUPERVISOR—Age 38, 15½ years experience. Capable of full responsibility. Can set up and get out production on all phases of plating and polishing, automatic and hand operated lines, trouble shooting and solution maintenance. Prefer southern states but will consider other sections. Reply Box S1, PLATING, 445 Broad St., Newark 2, N. J.

HELP WANTED

RESEARCH ASSOCIATE to work at the National Bureau of Standards, Washington, D. C. for A.E.S. Research Project No. 19 on the Galvanic Effects associated with coating failure. This is an opportunity for a chemist with research experience or post graduate work to conduct original research in an academic atmosphere. Publications are encouraged. Reply to Fielding Ogburn, National Bureau of Standards, Washington 25, D. C.

SALES MANAGER—Electrochemical, Metallurgical or plating background. Experienced direct mail and customer contact, sales letters, promotion and advertising. Long Island location. Send resume and salary expected. Reply Box S2, PLATING, 445 Broad St., Newark 2, N. J.

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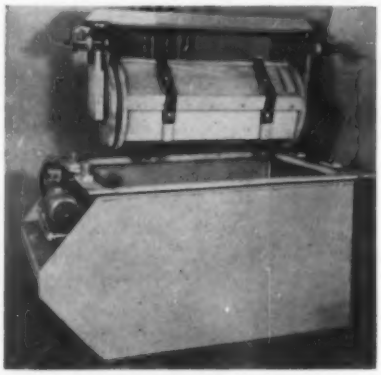

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September 14, 1961—**Dallas-Fort Worth Branch,** Annual Meeting and Dinner-Dance, Statler-Hilton Hotel, Dallas, Texas.

September 16, 1961—**Executive Board Meeting,** Buffalo, N. Y.

Sept. 21-22, 1961—**Editorial Board Meeting,** National Headquarters, Newark, N. J.

September 22, 1961—**Third Metropolitan Regional Technical Session,** New York Host Branch, Statler-Hilton Hotel, New York, N. Y.

September 29, 1961—**Research Committee Meeting,** National Headquarters, Newark, N.J. (Date change to Oct. 20 Imminent)

October 28, 1961—**Midwest Regional Council,** Third Annual Technical and Workshop Session, Argonne National Laboratories, Lemont, Illinois.

December 1, 1961—**Melbourne Branch Annual Dinner,** Melbourne, Australia

December 1-2, 1961—**Detroit Branch Annual Educational Meeting and Banquet,** Statler-Hilton Hotel, Detroit, Mich.

Dec. 15-16, 1961—**Newark Branch Annual Educational Session and Banquet,** Robert Treat Hotel, Newark, N. J.

December 16, 1961—**Bridgeport Branch Dinner-Dance,** Stratfield Hotel, Bridgeport, Conn.

January 12-14, 1962—**Executive Board Meeting,** Hotel Marott, Indianapolis, Indiana.

January 13, 1962—**Ninth Interim Meeting, Supreme Society,** Hotel Marott, Indianapolis, Ind.

January 20, 1962—**Grand Rapids Branch Annual Meeting,** Pantlind Hotel, Grand Rapids, Mich.

January 27, 1962—**Chicago Branch Annual Educational Meeting and Banquet,** Conrad Hilton Hotel, Chicago, Ill.

February 9-10, 1962—**Fourth Annual Dixie Regional Educational Meeting,** Dinkler-Plaza Hotel, Atlanta, Georgia

February 17, 1962—**New York Branch Annual Technical Session and Banquet,** Hotel Statler-Hilton, New York, N. Y.

March 2-3, 1962—**Philadelphia Branch Annual Educational Session and Banquet,** Benjamin Franklin Hotel, Philadelphia, Pa.

March 3, 1962—**Dayton Branch Annual Educational Session and Banquet,** Biltmore Hotel, Dayton, Ohio.

April 21, 1962—**23rd Annual New England Regional Meeting,** Hotel Statler, Hartford, Conn., Springfield Branch, Host.

May 1, 1962—**Central Michigan Branch,** Annual Educational Session and Banquet, Hotel Hayes, Jackson, Mich.

June 25-28, 1962—49th AES Annual Convention, Schroeder Hotel, Milwaukee, Wis. Sponsorship Midwest Regional Council.

June 24-27, 1963—50th AES Annual Convention, Ambassador Hotel, Atlantic City. N. J. Sponsorship Newark Branch.

June 15-18, 1964—51st AES Annual Convention, Sheraton-Jefferson Hotel, St. Louis, Missouri.

June 16-18, 1964—Sixth Industrial Finishing Exposition, St. Louis, Missouri.

June 28-July 1, 1965—52nd AES Annual Convention, Statler Hotel, New York, N. Y.

June 26-30, 1966—53rd AES Annual Convention, Hotel Fontainebleau, Miami, Florida. Dixie Regional Council, Sponsor. Southeastern Branch, Host.

June 1967—54th AES Annual Convention, Dallas, Texas

INTERSOCIETY

October 1-5, 1961—The Electrochemical Society, Fall Meeting, Hotel Statler, Detroit, Mich.

October 16-19, 1961—2nd International Congress on Vacuum Technology, Sheraton Park Hotel, Washington, D. C.

October 23-27, 1961—43rd National Metal Exposition & Congress, Cobo Hall, Detroit, Mich.

Nov. 26-Dec. 1, 1961—American Society of Mechanical Engineers, Winter Annual Meeting, Statler-HiltonHotel, New York, N. Y.

Jan. 30-Feb. 2, 1962—Society of Plastics Engineers, 18th Annual Technical Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

February 5-9, 1962—American Society for Testing Materials, Committee Week, Statler-Hilton Hotel, Dallas, Texas

March 6-7, 1962—Society of Vacuum Coaters. 5th Annual Technical Conference, Sheraton-Cleveland Hotel, Cleveland, Ohio

March 19-23, 1962—National Association of Corrosion Engineers, 18th Annual Conference, and Corrosion Show, Kansas City Auditorium, Kansas City, Mo.

May 6-10, 1962—The Electrochemical Society, Spring Meeting, Statler-Hilton Hotel, Los Angeles, Calif.

June 24-29, 1962—American Society for Testing Materials, Annual Meeting and Apparatus Exhibit, Statler-Hilton Hotel, New York, N. Y.

Sept. 16-20, 1962—The Electrochemical Society, Fall Meeting, Hotel Statler-Hilton, Boston, Mass.

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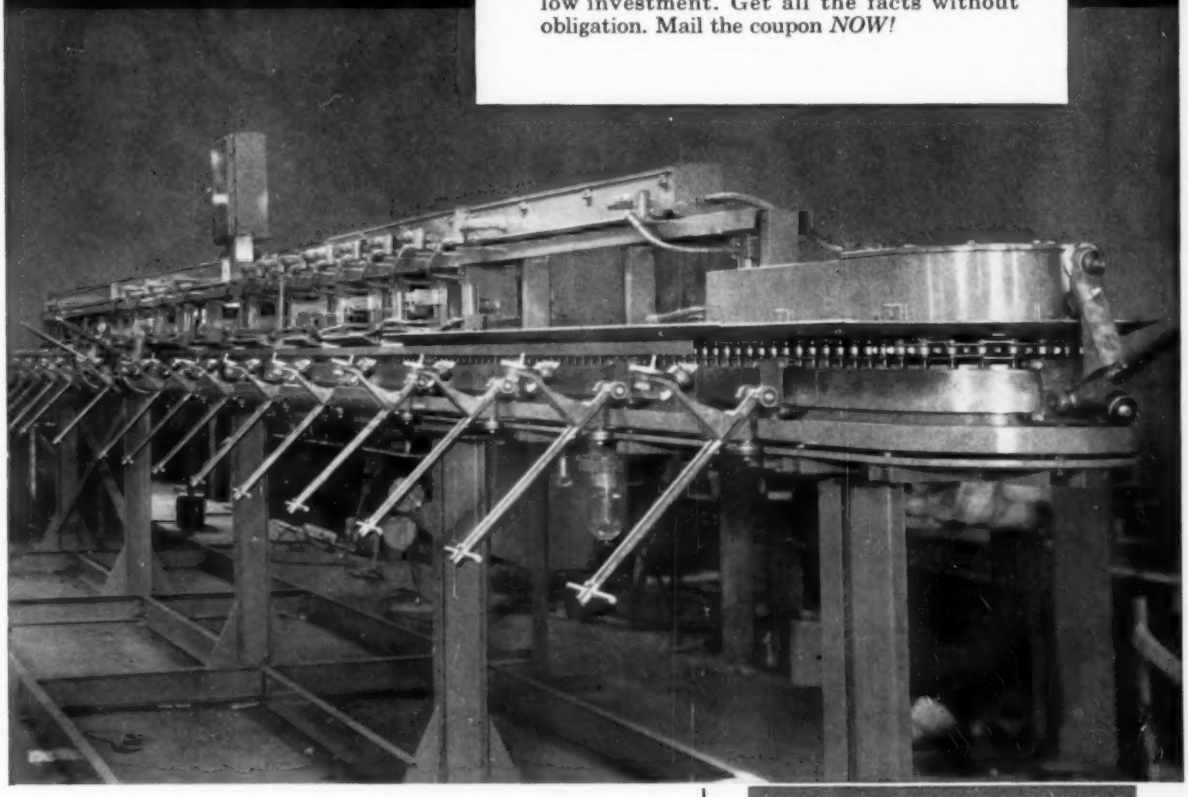

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